COMPLETED
594-C-5
FEM 1.209:060001/986/v.1
102

FLOOD INSURANCE STUDY

ORIGINAL

ALAMEDA COUNTY, CALIFORNIA
UNINCORPORATED AREAS

VOLUME 1 OF 2

REVISED: FEBRUARY 19, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER - 060001

BEST COPY AVAILABLE

TABLE OF CONTENTS

TABLE OF CONTENTS - VOLUME 1

		Page
1.0	INTRODUCTION	1
1.1	Purpose of Study	1
1.2	Authority and Acknowledgments	1
1.3	Coordination	1
2.0	AREA STUDIED	2
2.1	Scope of Study	2
2.2	Community Description	4
2.3	Principal Flood Problems	5
2.4	Flood Protection Measures	6
3.0	ENGINEERING METHODS	8
3.1	Hydrologic Analyses	8
3.2	Hydraulic Analyses	29
4.0	FLOOD PLAIN MANAGEMENT APPLICATIONS	33
4.1	Flood Boundaries	33
4.2	Floodways	34
5.0	INSURANCE APPLICATION	45
5.1	Reach Determinations	46
5.2	Flood Hazard Factors	46
5.3	Flood Insurance Zones	46
5.4	Flood Insurance Rate Map Description	53
6.0	OTHER STUDIES	54
7.0	LOCATION OF DATA	54
8.0	BIBLIOGRAPHY AND REFERENCES	54

BEST COPY AVAILABLE

TABLE OF CONTENTS - VOLUME 1 (Cont'd)

Page

FIGURES

Figure 1 - Vicinity Map..... 3
Figure 2 - Frequency-Discharge, Drainage Area Curves..... 10
Figure 3 - Floodway Schematic..... 45

TABLES

Table 1 - Tidal Frequency..... 30
Table 2 - Summary of Discharges..... 31
Table 3 - Floodway Data..... 35
Table 4 - Flood Insurance Zone Data..... 47

TABLE OF CONTENTS - VOLUME 2

EXHIBITS

Exhibit 1 - Flood Profiles

Alameda Creek	Panels 01P-06P
Arroyo De La Laguna	Panels 07P-12P
Arroyo Mocho	Panels 13P-20P
Arroyo Las Positas	Panels 21P-28P
Arroyo Seco	Panels 29P-32P
Arroyo Las Positas Relocation	Panels 33P-36P
Arroyo Del Valle	Panels 37P-42P
Tassajara Creek	Panels 43P-44P
Cottonwood Creek	Panel 45P
Collier Creek	Panel 46P
Cayetano Creek	Panels 47P-50P
Cayetano Creek (West Branch)	Panel 51P
Altamont Creek	Panels 52P-54P
Dublin Creek	Panel 55P
Chabot Canal	Panel 56P
San Lorenzo Creek	Panels 57P-66P
Palomares Creek	Panels 67P-69P
Cull Creek	Panel 70P
Crow Creek	Panels 71P-74P
Chabot Creek (Line G)	Panels 75P-76P
Castro Valley Creek (Line I)	Panels 77P-78P
Castro Valley Creek (Line J)	Panels 79P-80P
Sulphur Creek	Panel 81P
Ward Creek - Line B (Zone 3A)	Panel 82P

Exhibit 2 - Flood Boundary and Floodway Map Index
Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

BEST COPY AVAILABLE

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study report has been prepared to revise and update a previous Flood Insurance Study/Flood Insurance Rate Map for the unincorporated areas of Alameda County, California, which was published on April 15, 1981. This information will be used by Alameda County to update existing flood plain regulations as part of the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). The information will also be used by local and regional planners to further promote sound land use and flood plain development.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Development and Resources Corporation, for FEMA, under Contract No. H-3682. This study was completed in March 1976.

1.3 Coordination

Throughout the production of this study, the staff of the Alameda County Flood Control and Water Conservation District provided significant assistance to the Development and Resources Corporation. The extensive map and drawing files of the county agency were made available for the study. They form a large part of the physical basis for the development of flood plains.

Additional coordination was established with the Alameda County Planning Department and the Alameda County Department of Public Works, National Climatic Center, National Weather Service, U.S. Geological Survey (USGS), the California Department of Water Resources, and the California Department of Transportation.

The U.S. Army Corps of Engineers (COE), San Francisco District, coordinated hydrologic and channel cross section data while maintaining close coordination with the City of Livermore Flood Insurance Study, which was conducted at the same time.

BEST COPY AVAILABLE

The results of this study were reviewed at a final community coordination meeting held on January 9, 1976. Attending the meeting were representatives of FEMA, the study contractor, and the county. The local communities were in complete accord with the results of this Flood Insurance Study. This study incorporates all appropriate comments, and all problems have been resolved.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the unincorporated areas of Alameda County, California. The area of study is shown on the Vicinity Map (Figure 1).

The Cities of Oakland, Albany, Berkeley, Emeryville, Alameda, Piedmont, San Leandro, Hayward, Union City, Fremont, Newark, Livermore, Pleasanton, and Dublin were not included in this study.

The study includes streams in two major basins and two minor basins. Streams studied in the San Lorenzo Creek basin include Palomares, Cull, Crow, Castro Valley, and Chabot Creeks.

Bockman Canal and Sulphur Creek drain a portion of the lowlands south of Hayward into San Francisco Bay, as well as Lines N-2 and N-3.

The Alameda Creek basin drains an area primarily east of the Coast Range to San Francisco Bay through Niles Canyon. This Flood Insurance Study includes the northern half of the basin, which is the area drained by Arroyo De La Laguna.

Included in the detailed study are a portion of Alameda Creek and Arroyo De La Laguna, in addition to Dublin Creek, Chabot Canal, and a series of constructed drainage canals; the Arroyo Mocho basin, including Tassajara Creek, Arroyo Seco, Arroyo Las Positas, Arroyo Las Positas Relocation; Arroyo Del Valle and the streams draining into Arroyo Las Positas; Arroyo Mocho from the north, including Cayetano Creek, Altamont Creek, Cottonwood Creek, Cayetano Creek (West Branch), and Collier Creek.

Ward Creek-Line B (Zone 3A) was studied in detail in the City of Hayward and affects portions of Alameda County.

Portions of the San Francisco Bay were studied by detailed methods.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 1981.

BEST COPY AVAILABLE

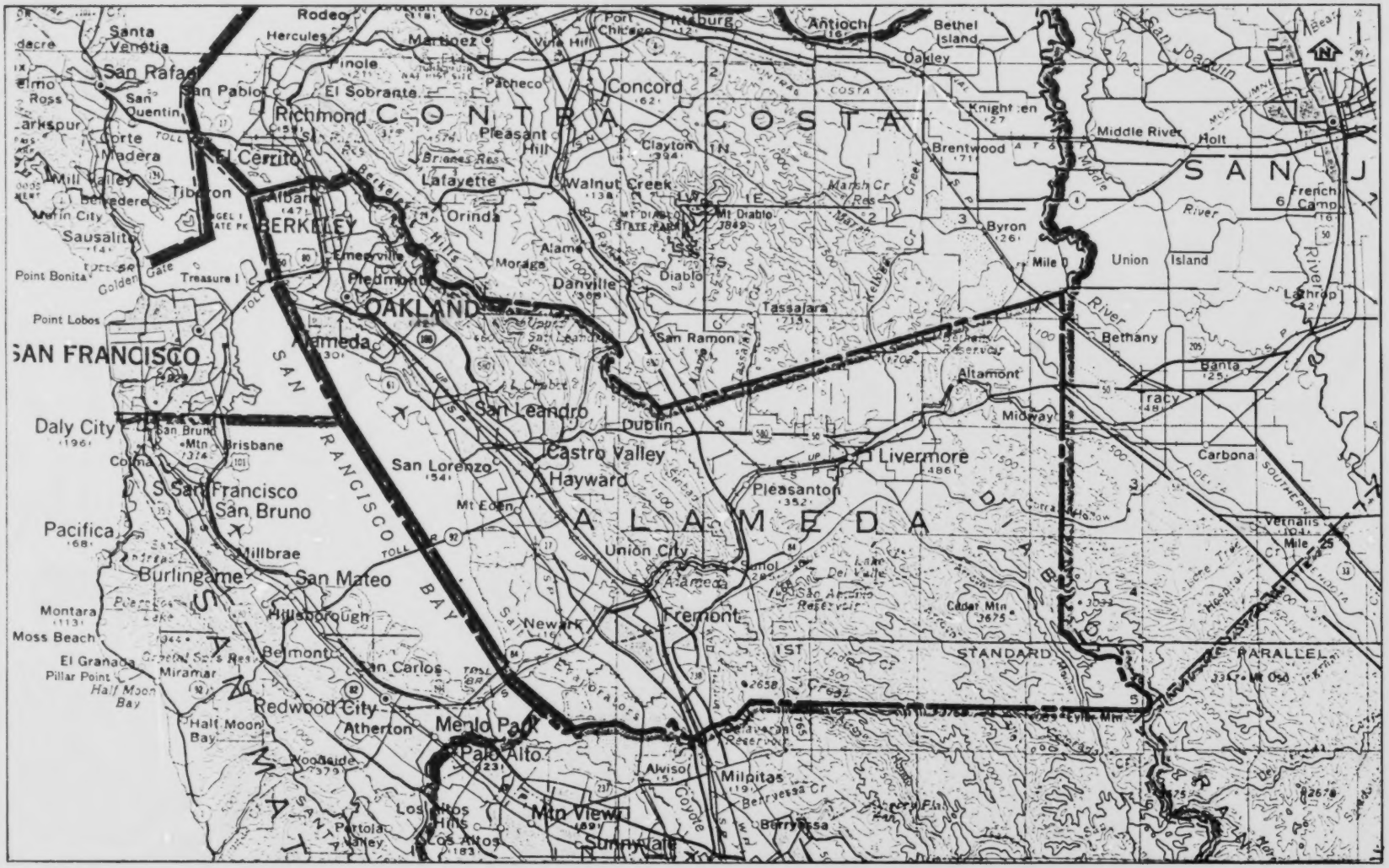


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

APPROXIMATE SCALE

8 0 8 16 24 MILES

VICINITY MAP

BEST COPY AVAILABLE

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and Alameda County.

2.2 Community Description

Alameda County, located in west-central California, lies adjacent to the Counties of Santa Clara, San Mateo, San Francisco, Contra Costa, and San Joaquin. Along its western side, Alameda County is bordered by San Francisco Bay. Of the 715 square miles in Alameda County, approximately 480 square miles are unincorporated.

The Alameda Creek basin covers an area of approximately 700 square miles within Alameda, Santa Clara, and Contra Costa Counties. Alameda Creek originates in Santa Clara County and flows northwesterly through the hills of the Coast Range in Alameda County, crosses the flat San Francisco Bay plain, and discharges into San Francisco Bay. Major water bodies in this basin include Del Valle, Calaveras, and San Antonio Reservoirs. In Alameda County, the Alameda Creek basin has a maximum elevation of approximately 3,800 feet; the lowest elevation is at sea level where the creek discharges into San Francisco Bay. Tributaries in the Alameda Creek basin within the study area flow through narrow canyons in the hills, traverse the Livermore-Amador Valley, and empty into Arroyo De La Laguna. Arroyo De La Laguna carries the combined flows into Alameda Creek, which it joins near Sunol.

Northwest of the Alameda Creek watershed, the San Lorenzo Creek basin drains a fan-shaped area of approximately 60 square miles within Alameda and Contra Costa Counties. Major tributaries to San Lorenzo Creek join in the southern and eastern sections of Castro Valley and their combined waters flow westerly into San Francisco Bay. No major bodies of water lie in the San Lorenzo Creek basin. The upper portion of the San Lorenzo Creek basin contains narrow, relatively steep valleys carved by tributaries. Ridges, ranging from 200 to 1,850 feet, divide the valleys. At its lower reach, San Lorenzo Creek crosses the San Francisco Bay plain, which descends gradually from an elevation of 100 feet at the foot of the Coast Range to sea level at San Francisco Bay.

The climate in Alameda County is characterized by warm, dry summers and mild, wet winters. The City of Livermore, in the Livermore-Amador Valley, has an average annual temperature of approximately 59°F (Reference 1). Rainfall is the chief form of precipitation in the basins, although at higher elevations snow falls occasionally. Precipitation in the Alameda and San Lorenzo Creek basins ranges from 12 to 36 inches (Reference 1), varying by location with respect to the mountains which channel rain-producing air currents. The heaviest annual precipitation occurs in the southeastern corner of the county.

BEST COPY AVAILABLE

Natural vegetation in Alameda County consists chiefly of grasses, with oak trees found in valleys and hillside gullies, and on north- and east-facing slopes. Laurel and alder trees are abundant in canyon bottoms, and willows are common along watercourses. Chaparral and thick growths of oak trees are found in the southeastern corner of the county.

The historical development of Alameda County is typical of west-central California. Alameda County was once occupied by Indians of the Penutian family. In the early 19th century, ranches and farms were established by Spanish and Mexican settlers. In the mid-1800s, some of the immigrants initially drawn to California by the gold rush started small villages in the area, and in 1853 Alameda County was founded. The population of Alameda County has increased from 130,200 in 1900 to 1,071,446 in 1970; during the 10 years from 1960 to 1970, the population increased by 18 percent (Reference 2). Future growth is expected to become more gradual (Reference 3). In 1970, 135,134 people, or 12.6 percent of the total county population, resided in unincorporated areas (Reference 4); and in 1973, an estimated 138,500 people, or 12.1 percent of the county residents, lived in unincorporated areas (Reference 5).

The flood plains of the Alameda Creek watershed, in unincorporated portions of the Livermore-Amador Valley, are used for housing, parks and recreational areas, industry, and agriculture. In the hills surrounding the Livermore-Amador Valley, flood plains are chiefly contained within narrow, undeveloped canyons. Flood plain land in the unincorporated areas within the San Lorenzo Creek watershed is devoted principally to residential development, with some commercial use. Public utilities, roads, highways, and railroads have been constructed throughout the flood plains of the Alameda Creek and San Lorenzo watersheds. Without controls, further development of the flood plains can be expected.

2.3 Principal Flood Problems

Factors that induce flooding in Alameda County are winter storms of heavy rainfall, a steep topography, and constricted floodways. Storms of wide areal distribution originate over the Pacific Ocean in winter and develop with the frontal lifting of airmasses along the hills of the Coastal Range.

Concentration of storm runoff is rapid in the areas of steep slope found in the middle and upper portions of the Alameda and San Lorenzo Creek basins. Many tributaries through the two basins are ephemeral and have narrow channels that cannot accommodate higher flows. Numerous stream crossings have been built that also constrict heavy flows. In some parts of the Alameda and San Lorenzo Creek watersheds, buildings have encroached upon the flood plains. Flood plain development and constriction of channels cause elevated floodflows that result in increased flood damage.

BEST COPY AVAILABLE

Large floods occurred in the Alameda Creek watershed in 1862 and 1911. More recently, large floods took place in 1950, with damage estimated at $1,100,000; in 1952, with damage estimated at $1,500,000; in 1955, with damage estimated at $3,700,000; and in 1958, with damage estimated at $1,850,000 (Reference 6). Numerous less-damaging floods took place from 1863 to 1888. From 1889 to 1910 five major floods and five less-damaging floods occurred. Between 1912 and 1945 two major floods and 16 less-damaging floods occurred.

Historical accounts indicate that major flooding of San Lorenzo Creek took place in the winters of 1861-62, 1866-67, 1871-72, and 1880-81 (Reference 7).

More recent major floods of San Lorenzo Creek occurred in January 1911, January 1916, February 1919, February 1925, December 1931, February 1940, January 1942, December 1950, December 1955, and April 1958 (Reference 7).

Flood damages still occur along major tributaries of Alameda and San Lorenzo Creeks. In 1962, flooding in the unincorporated areas of Alameda County, in combination with mud slides and gale winds, caused the region to be declared an emergency area. A later flood was described in a newspaper account from the Hayward Daily Review, December 23, 1964 (Reference 8), as having knocked out power, flooded homes, and closed roads after a heavy storm dropped 3 inches of rain on Alameda County.

In January 1970, flooding throughout Alameda County closed roads and caused creek banks to erode in the unincorporated areas.

Effects of floods that currently threaten unincorporated areas of Alameda County are traffic congestion and damages to buildings, utilities, crops, roads, and highways.

2.4 Flood Protection Measures

The COE have constructed local flood-control projects that include improvements along Alameda and San Lorenzo Creeks. Both projects involve construction of concrete channel, riprap-lined channel, graded earth channel, and levee sections. The design capacities of the 12 mile Alameda Creek Project are 51,000 cubic feet per second (cfs) from the mouth of Niles Canyon downstream to Dry Creek and 52,000 cfs from Dry Creek to the San Francisco Bay. The San Lorenzo Creek Project is a 7-mile-long channel improvement that protects the City of Hayward and the Village of San Lorenzo from flooding. The design capacities of the channel are 9,200 cfs from the upper limits of the project at B Street, downstream to Castro Valley Creek, and 10,000 cfs from Castro Valley Creek to the San Francisco Bay.

BEST COPY AVAILABLE

The Del Valle Dam, located on Arroyo Del Valle, a tributary of Alameda Creek, was completed in 1968 by the California Department of Water Resources as a part of the South Bay Aqueduct Project. This earth dam receives runoff from an area of approximately 150 square miles. The maximum spillway peak discharge is at 7,000 cfs.

Since the 1958 floods, both Alameda and San Lorenzo Creeks have been channelized along their lower reaches and impoundments have been constructed to reduce flooding. The Alameda County Flood Control and Water Conservation District owns and operates dams in the Alameda and San Lorenzo Creek watersheds and maintains a number of flood-control channels. In 1963 the district constructed a dam and channel improvements on Cull Creek, a tributary of San Lorenzo Creek. The dam now controls sedimentation and lowers flood peaks from a 6 square mile area. Don Castro Dam, which receives runoff from an area of 20 square miles in the San Lorenzo Creek watershed, was built by the district in 1964. The spillway crest elevation is 230.0 feet. The maximum peak discharge is approximately 3,175 cfs.

The Bockman Canal system was constructed by the district to drain portions of San Leandro. The canal, which drains into San Francisco Bay, consists of earth and concrete trapezoidal channels.

Calaveras Dam was built on Calaveras Creek, a tributary to Alameda Creek, by the City of San Francisco in 1925. The Calaveras Dam Reservoir controls runoff from a total area of 100 square miles and receives diverted water from upper Alameda Creek via the Upper Alameda Creek Diversion Dam. The spillway crest elevation of the Calaveras Dam is 752.6 feet. In 1964, the City of San Francisco constructed a dam on San Antonio Creek, a tributary of Alameda Creek. The resulting San Antonio Reservoir impounds drainage water from a 40 square mile area. The spillway crest elevation is 468.0 feet with a design discharge of 13,500 cfs.

Numerous small livestock pond dams throughout the county retain runoff water, and local levees have been constructed along waterways and tidal land. Such flood-control measures have been largely carried out by private landowners.

Two regional parks have been established on flood plains in Alameda County by the East Bay Regional Planning District. The Coyote Hills-Alameda Creek Aquatic Park, completed in 1967, is located near the mouth of Alameda Creek at San Francisco Bay. The land, leased from the Alameda County Flood Control and Water Conservation District, occupies an area of approximately 950 acres that was once subject to flooding by Alameda Creek. Flood-control works now protect the land from Alameda Creek floodwater, although local runoff creates flood conditions as it drains into the park. Shadow Cliff Regional Park, completed in 1974, features water-based recreation. The 260-acre park is located east of Pleasanton on Arroyo Del Valle.

BEST COPY AVAILABLE

The Alameda County Planning Commission will soon consider draft amendments to the General Plan that include policies for curbing development of flood plains in the county. Policies have already been adopted by the commission to discourage development of county open space land, including some of the flood plain areas. The Planning Commission has designated portions of the flood plains of most creeks in the study as "connecting open space corridors" (Reference 9). Such corridors, generally strips of land along streams, are to be set aside for scenic driving routes or trails.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the county.

Two main stream basins and several hundred square miles of drainage area are included in Alameda County. Different procedures were used in different parts of the county to arrive at adopted stream discharges. The procedure adopted depended on the availability of data and previous studies in the particular area. In general, the priority of approach was to examine completed flood hydrology studies first. Streamflow gage records were then analyzed. Finally, the derivation of unit hydrographs at streamflow gage locations and the application of rainfall-runoff relationships using the HEC-1 computer program completed the analyses (Reference 10).

BEST COPY AVAILABLE

The results of hydrologic analyses generally reflect the 1975 level of development in the county. Significant changes in land use will require some updating of peak discharges.

Peak discharge-drainage area relationships for streams in the county are shown in the Frequency-Discharge, Drainage Area Curves (Figure 2).

The hydrologic data for the San Lorenzo Creek and Alameda Creek basins were developed as follows:

a. Within the San Lorenzo Creek basin, hydrologic studies were required on Palomares, Cull, Crow, Chabot, and Castro Valley Creeks. A USGS streamflow gage on San Lorenzo Creek at B Street in Hayward was used as a control point. A peak-flow frequency curve prepared by the COE, San Francisco District, was adopted for this location.

   In the Crow and Cull Creek basin and the Palomares basin, unit hydrographs were derived using regional data and a rainfall-runoff model was developed. Storms of various frequencies were applied to the model, and the model was adjusted so that the 100-year storm would produce a 100-year frequency flow at the B Street gage, the control point. Other frequency storms were calculated in the same manner. Flow frequency curves derived in this manner for each subbasin are consistent with the adopted frequency curve at the control point.

   The flow in Cull Creek is controlled by a flood detection reservoir, and the operating curve for this reservoir was used to define outflow.

   Chabot Creek and its tributary, Castro Valley Creek, drain into San Lorenzo Creek in the City of Hayward. Castro Valley is highly urbanized and is situated on a relatively steep slope. A USGS streamflow gage is located near the mouth of Castro Valley Creek. This gage, with 4 years of record, is inadequate for use in developing peak-flow frequency curves. Using recorded runoff data and measured precipitation for actual storms that occurred between 1971 and 1973, a unit hydrograph was derived for the gage location. This unit hydrograph was used in conjunction with regional relationships developed by the COE to define unit hydrographs at selected points throughout the basin. A rainfall-runoff model was developed, storms of various frequencies were applied, and peak-flow frequency curves were developed at each selected point.

b. The previous work of the COE on the Alameda Creek basin was reviewed and a frequency curve was developed for Alameda

BEST COPY AVAILABLE

BLANK PAGE

BLANK PAGE

BLANK PAGE

BEST COPY AVAILABLE

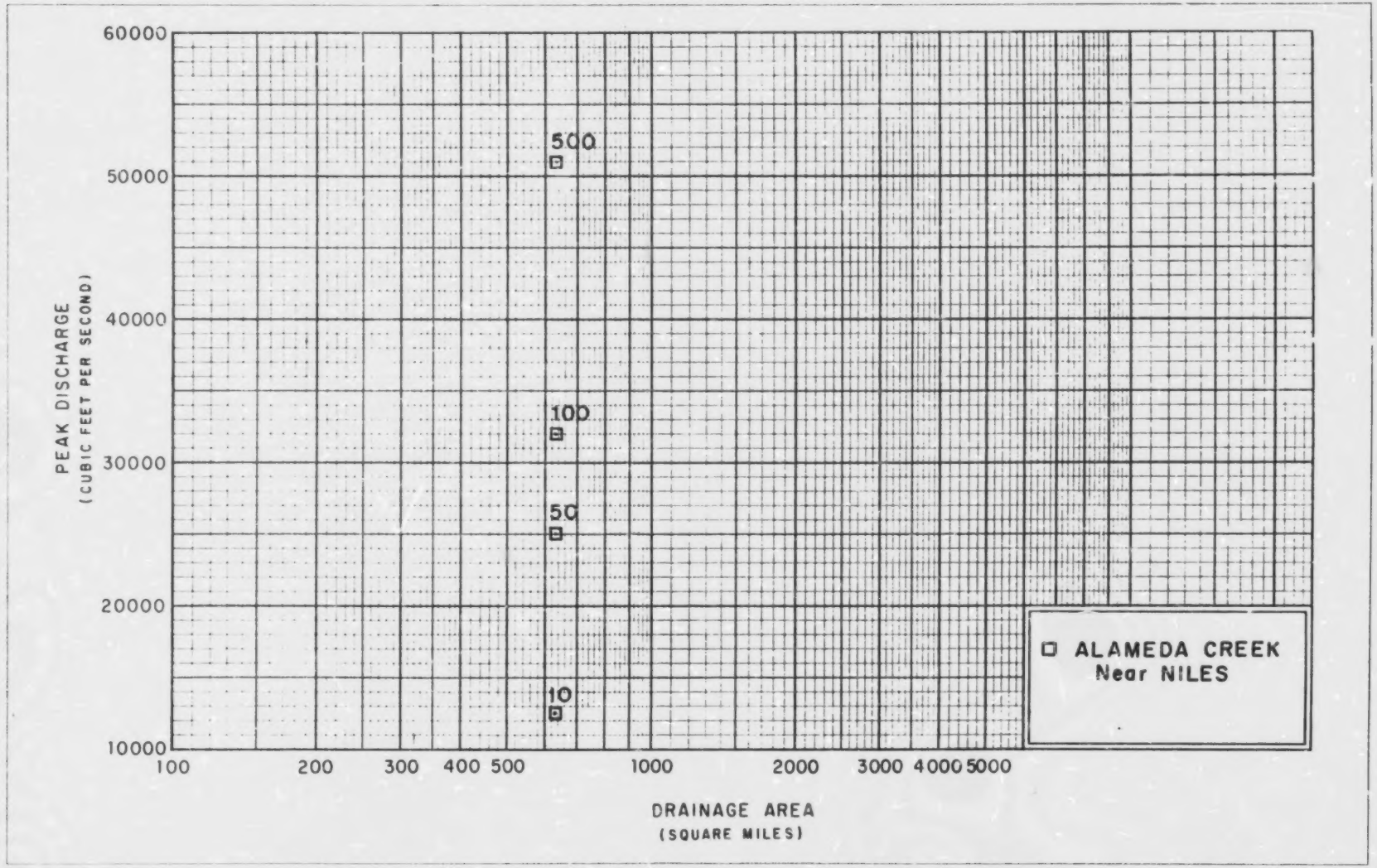


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ALAMEDA CREEK (NEAR NILES)

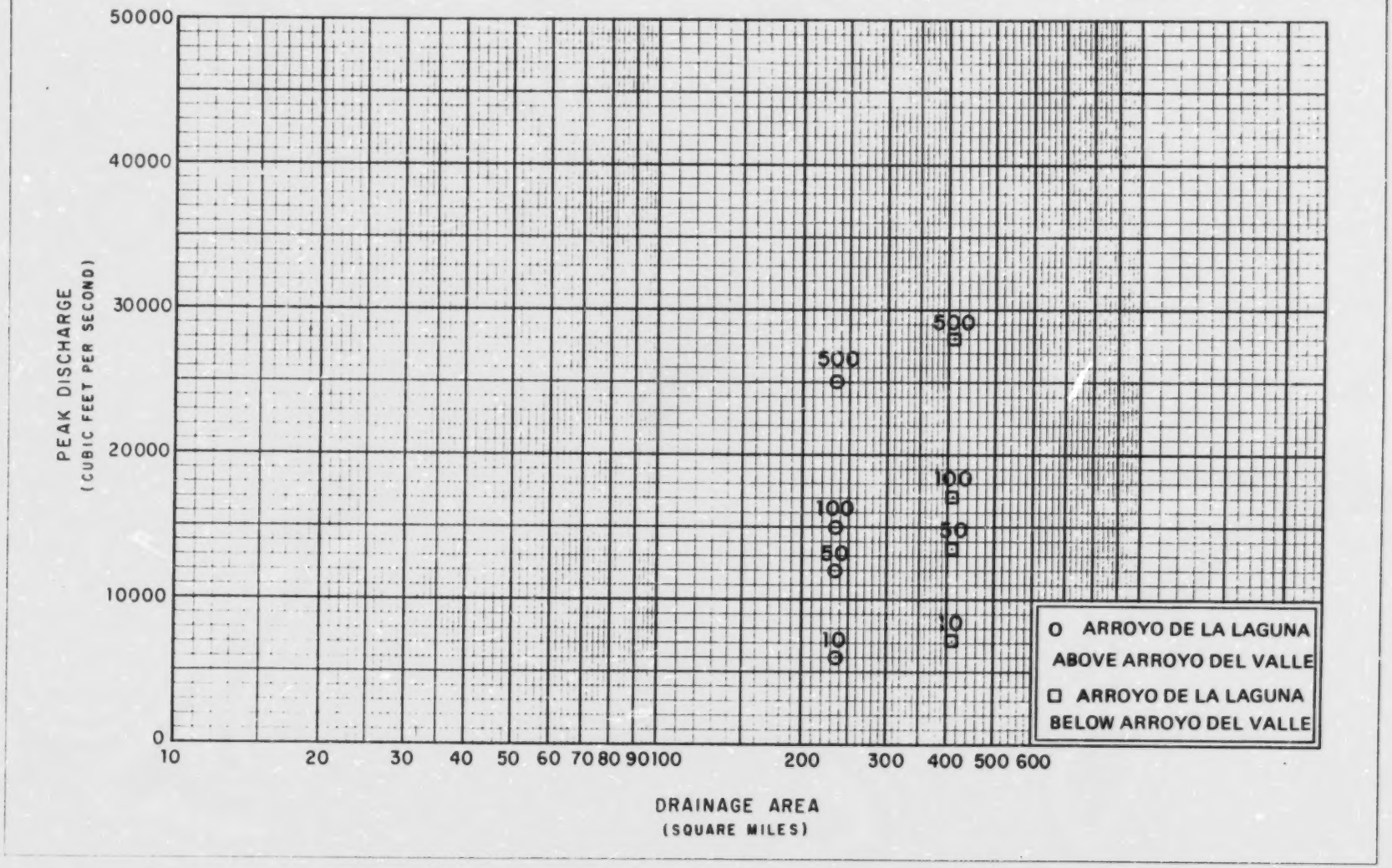


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ARROYO DE LA LAGUNA

BEST COPY AVAILABLE

BEST COPY AVAILABLE

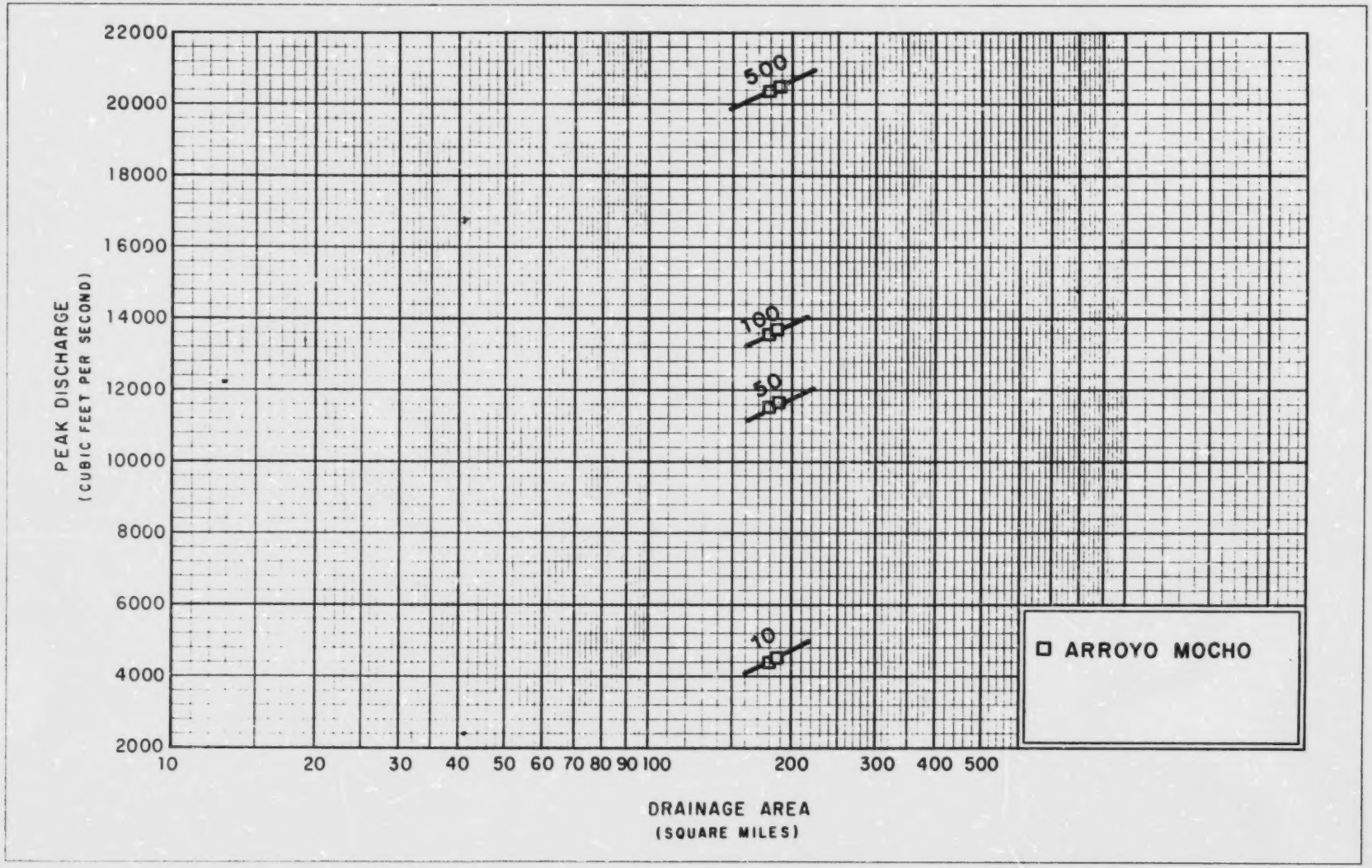


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ARROYO MOCHO

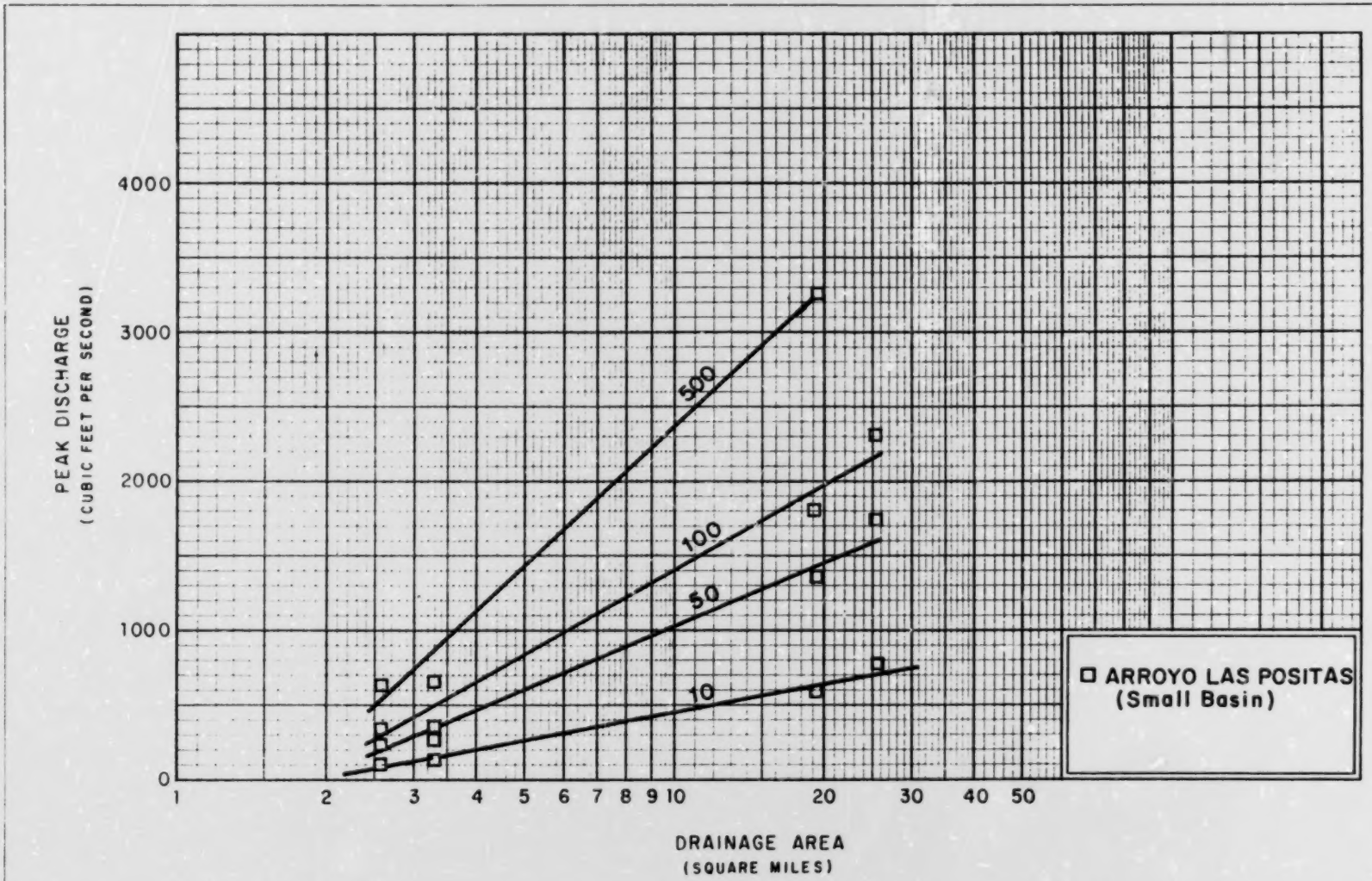


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ARROYO LAS POSITAS

BEST COPY AVAILABLE

BEST COPY AVAILABLE

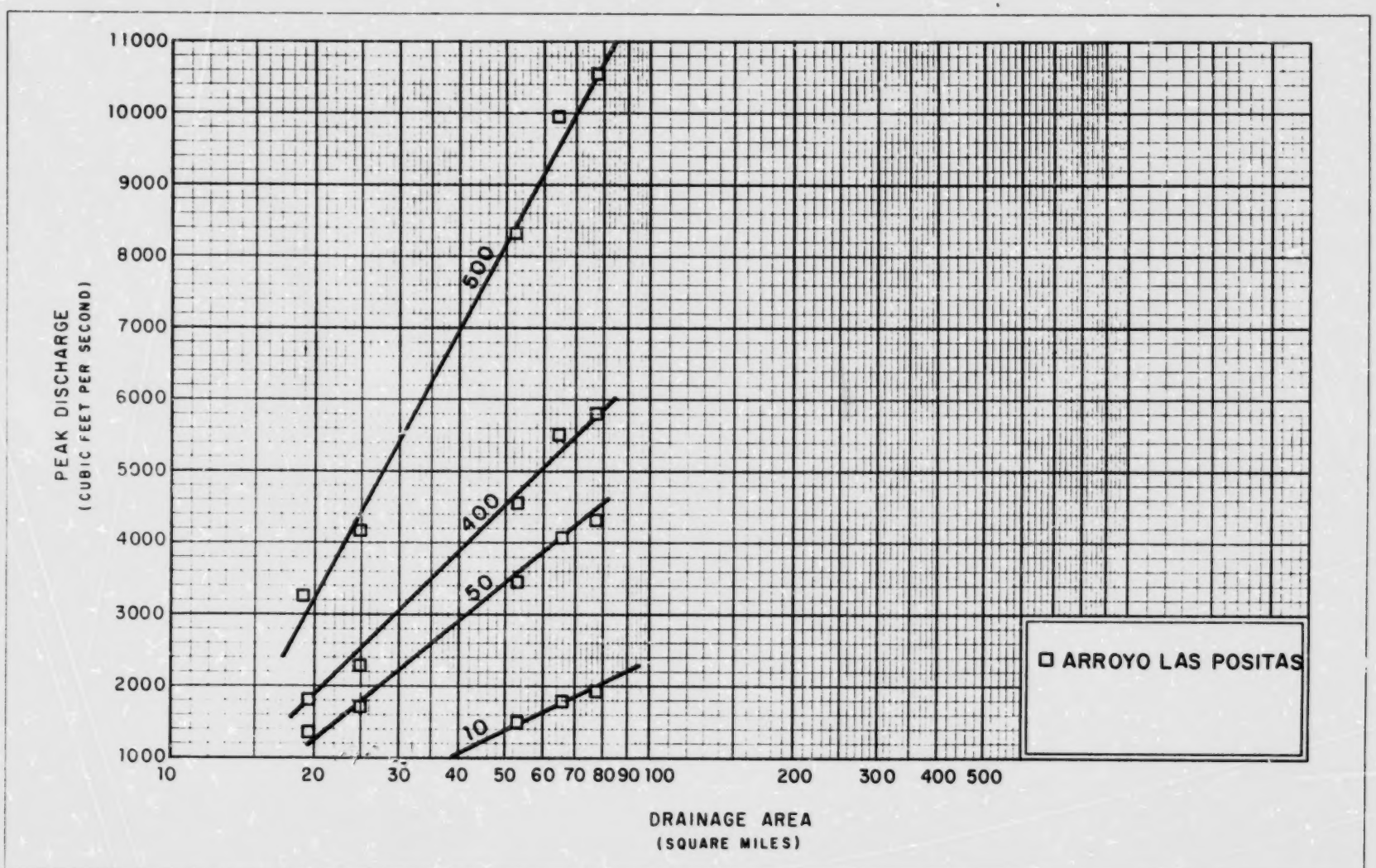


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ARROYO LAS POSITAS

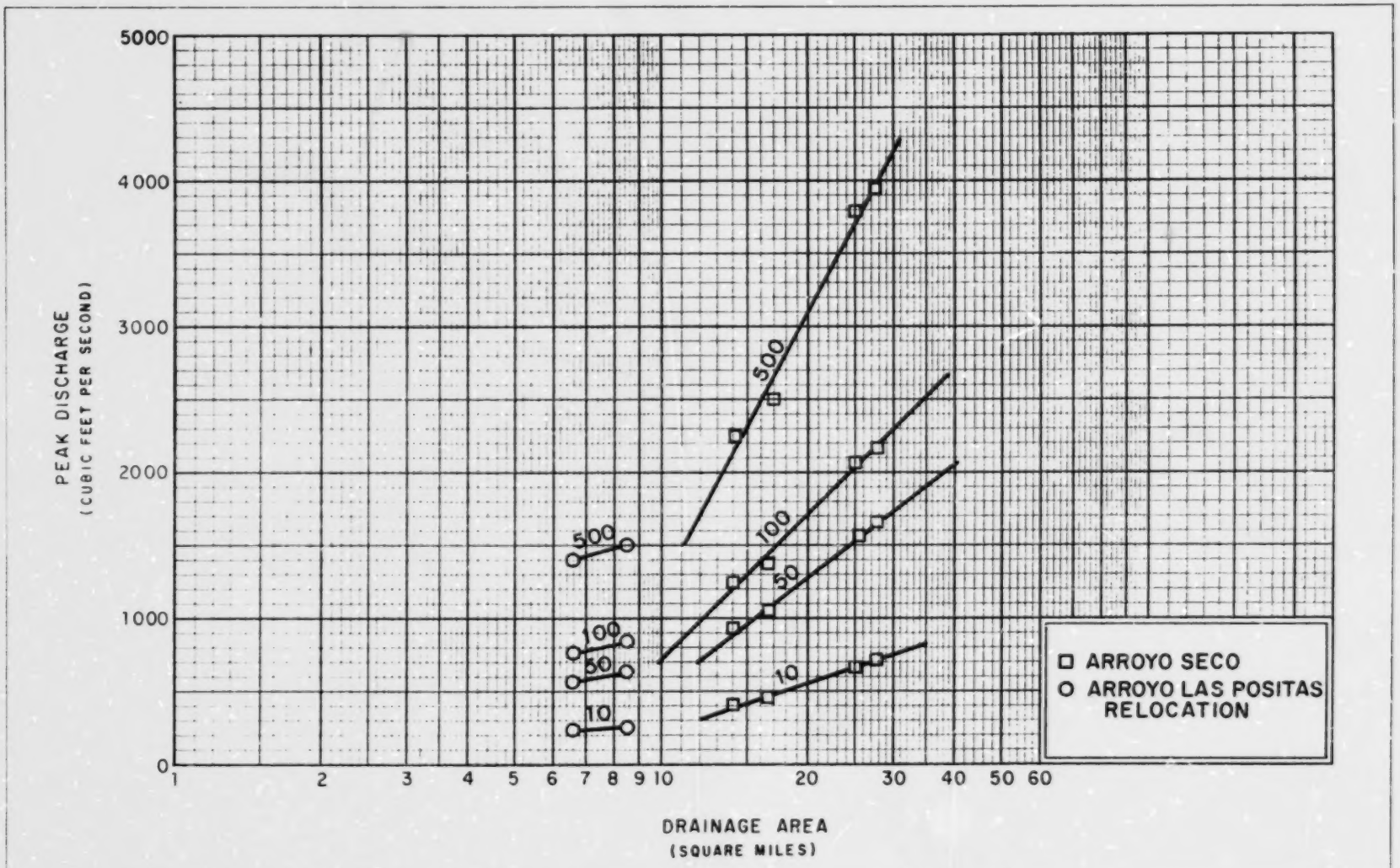


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ARROYO SECO, ARROYO LAS POSITAS RELOCATION

BEST COPY AVAILABLE

BEST COPY AVAILABLE

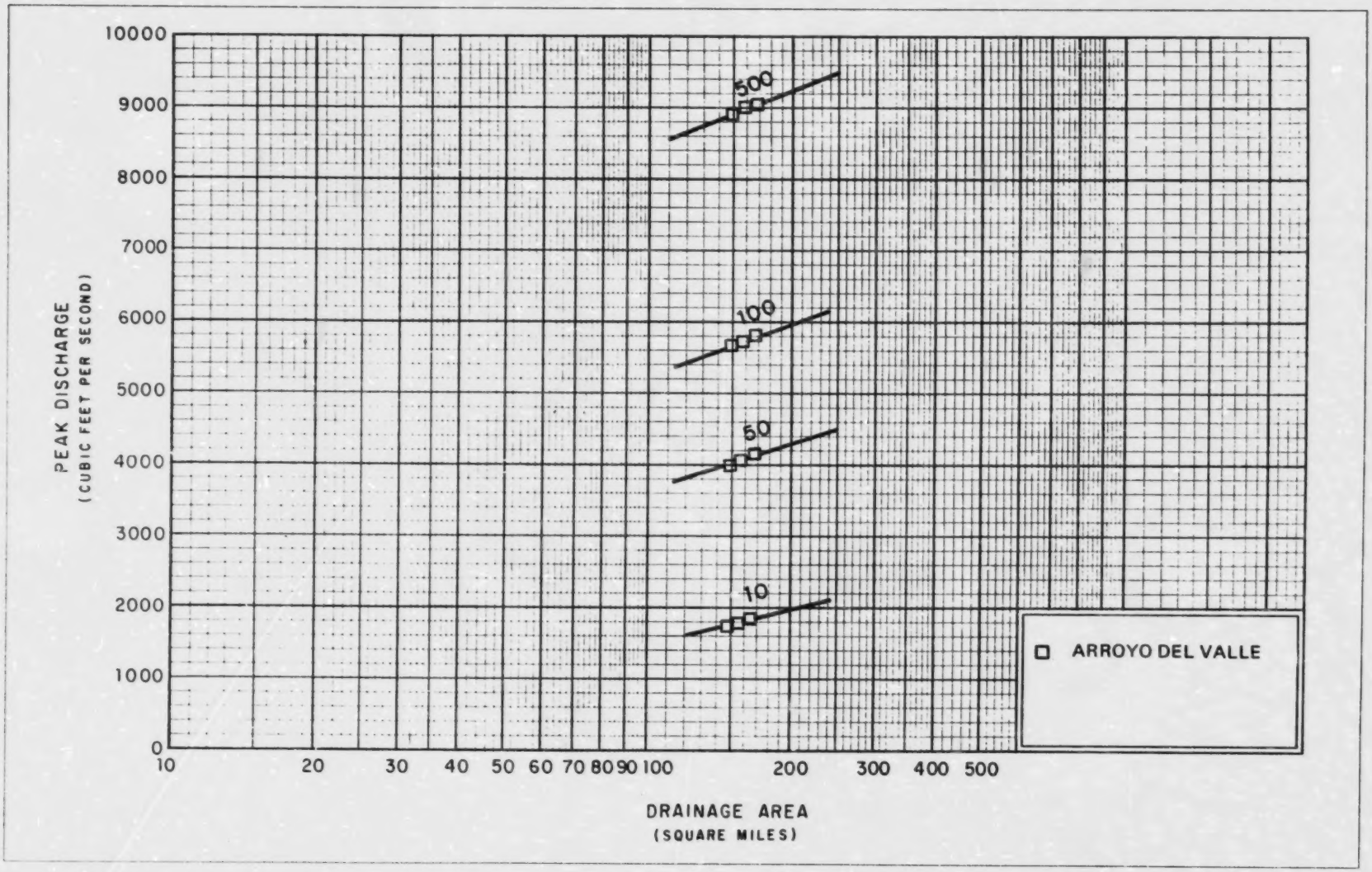


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ARROYO DEL VALLE

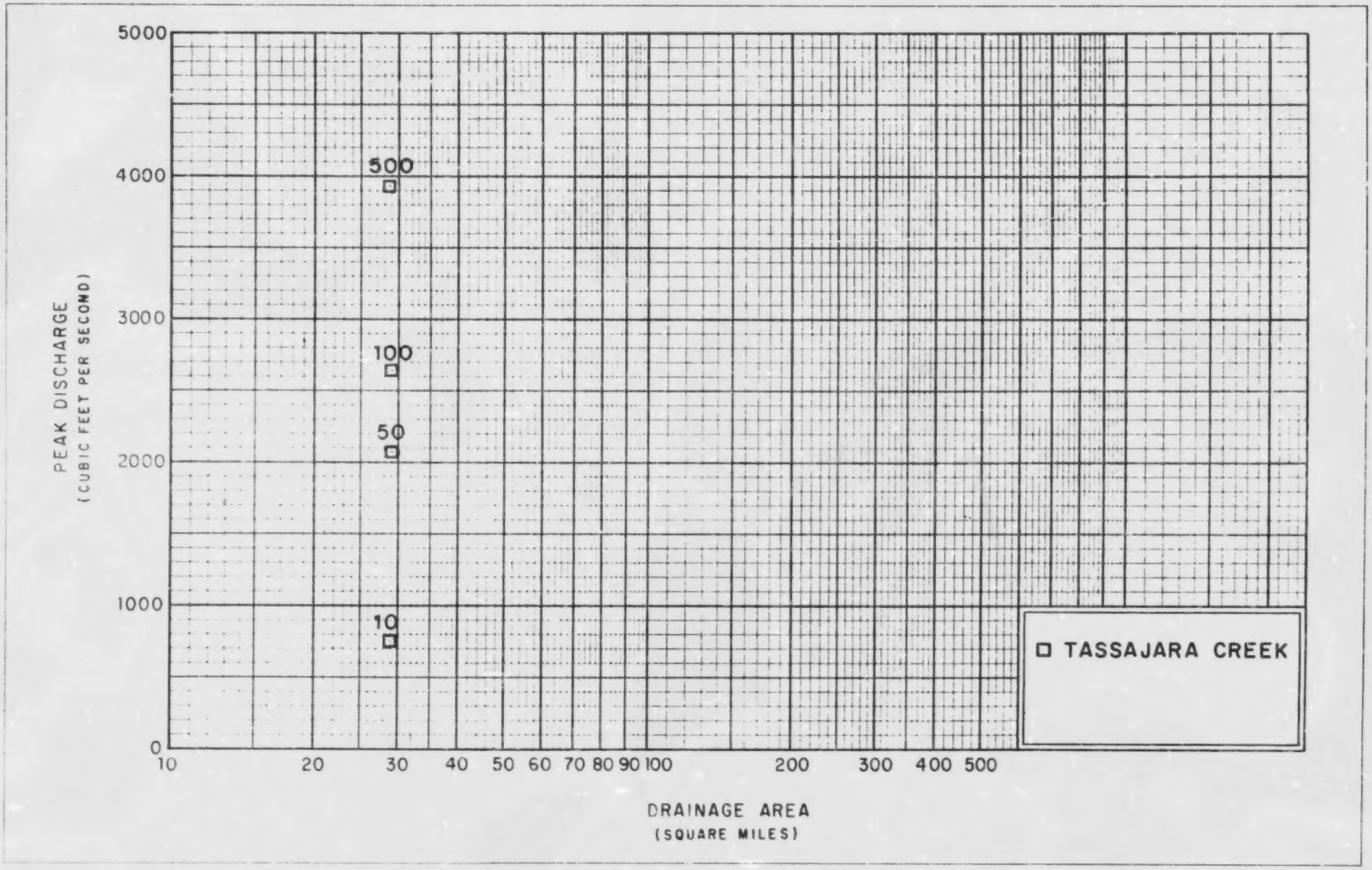


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

TASSAJARA CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

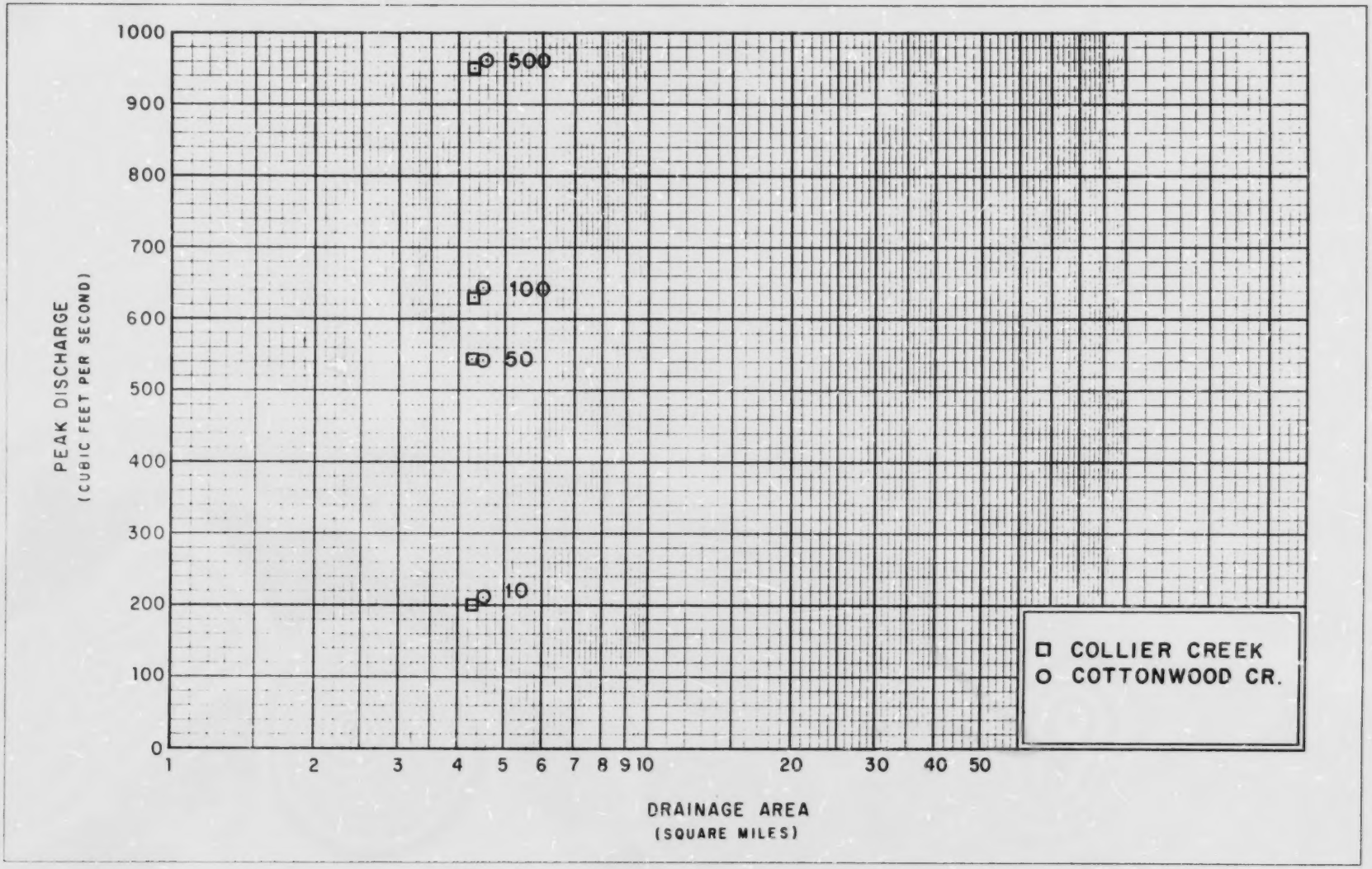


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

COLLIER CREEK, COTTONWOOD CREEK

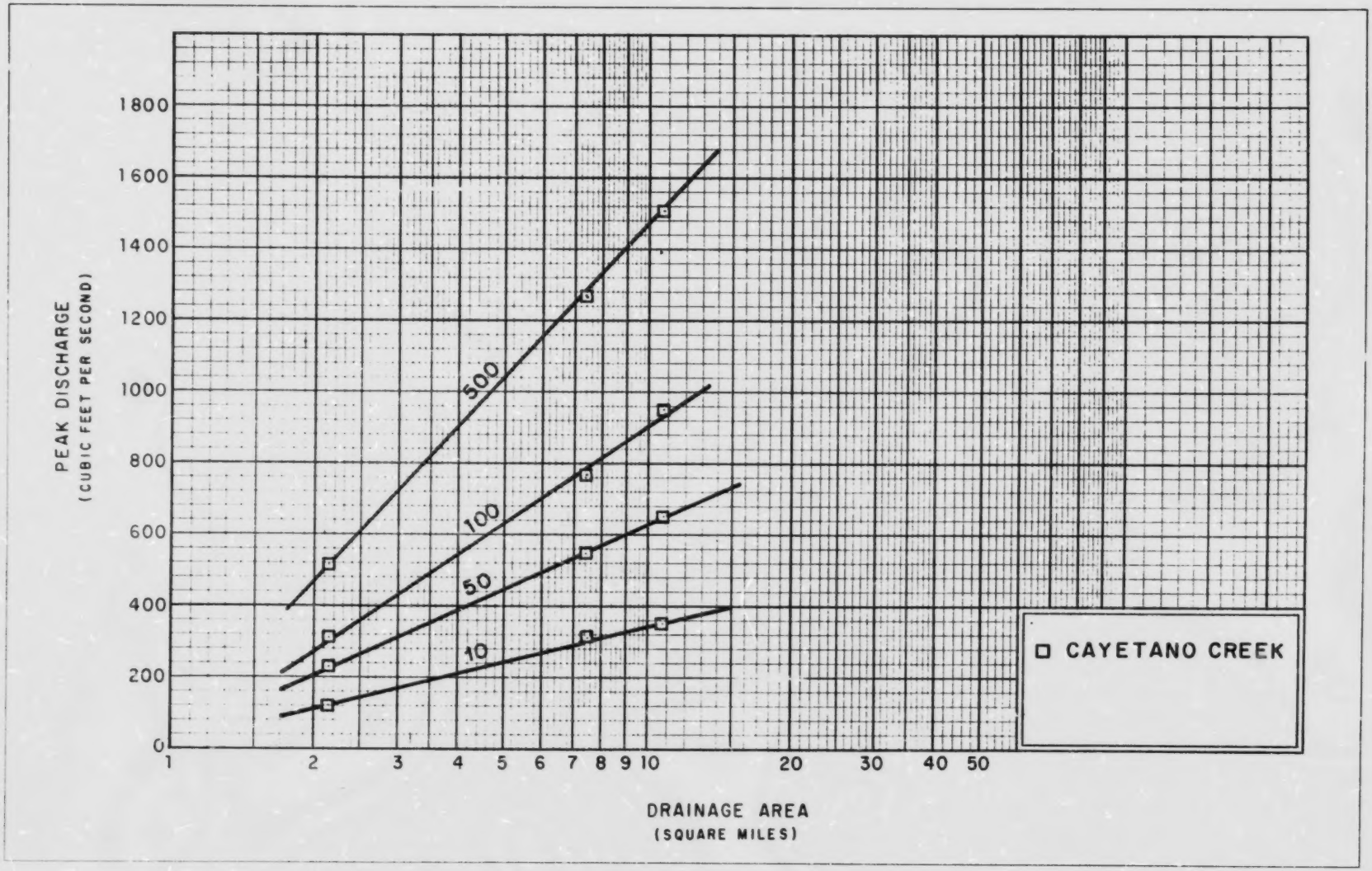


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CAYETANO CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

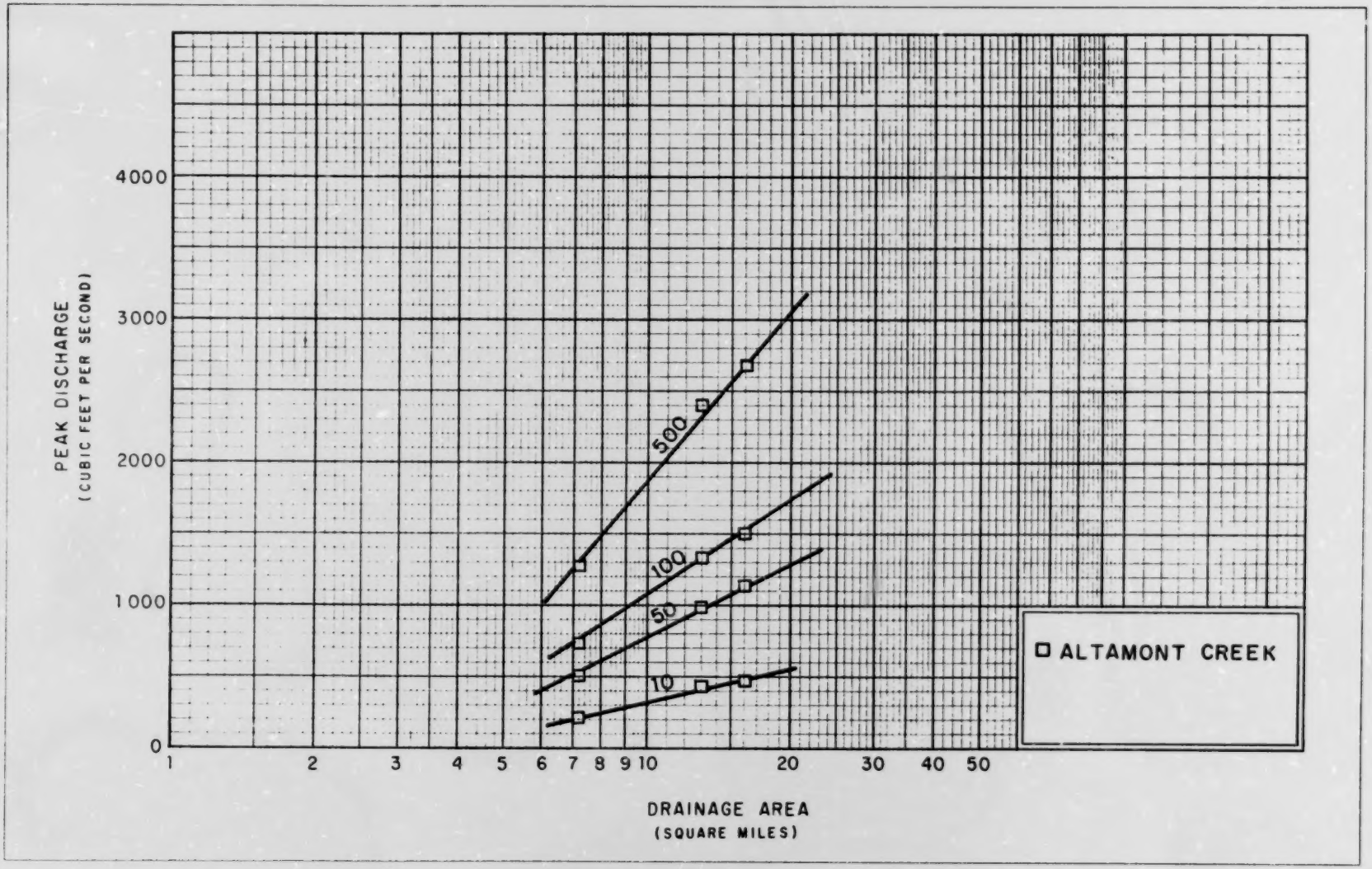


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

ALTAMONT CREEK

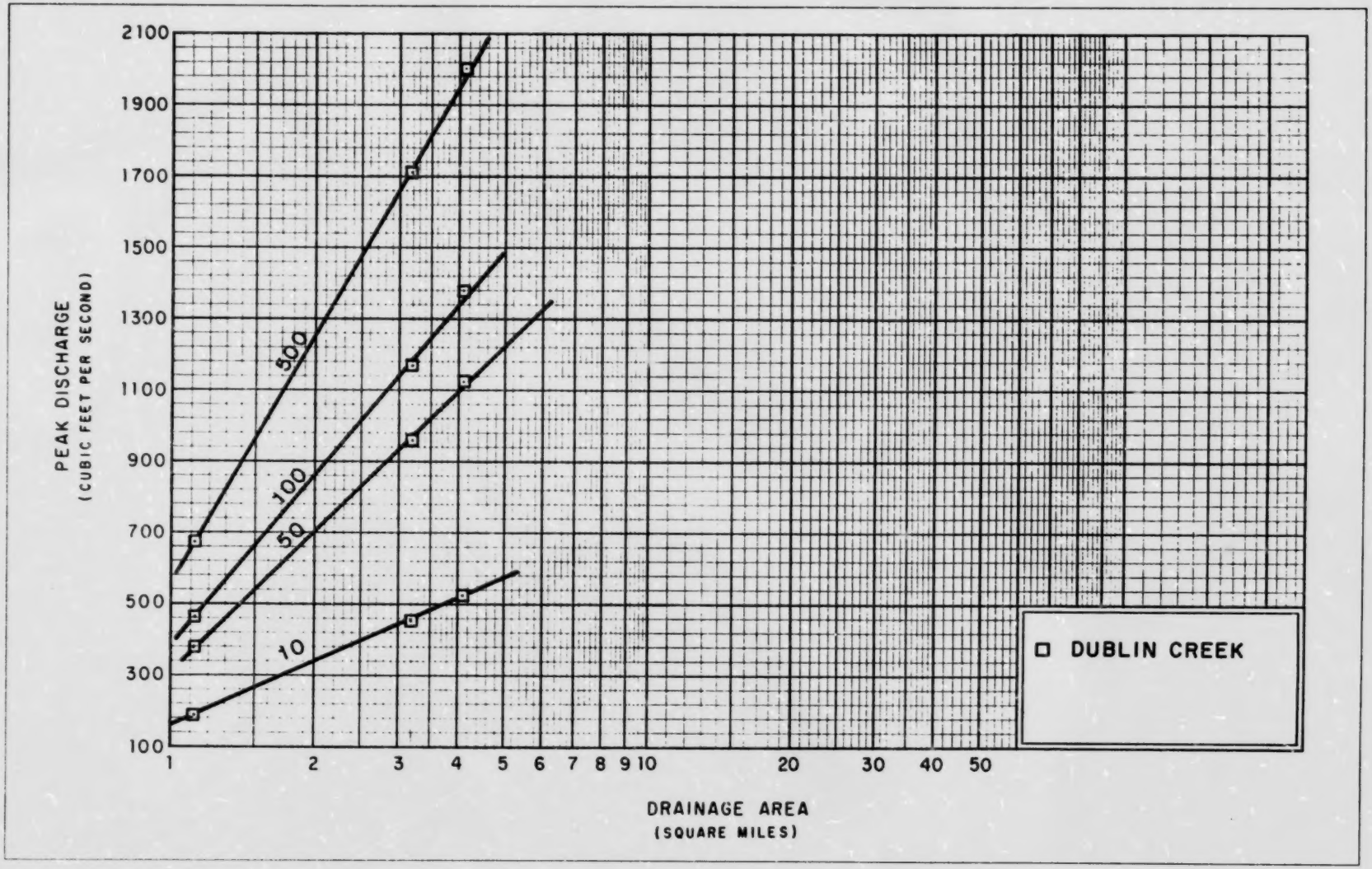


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

DUBLIN CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

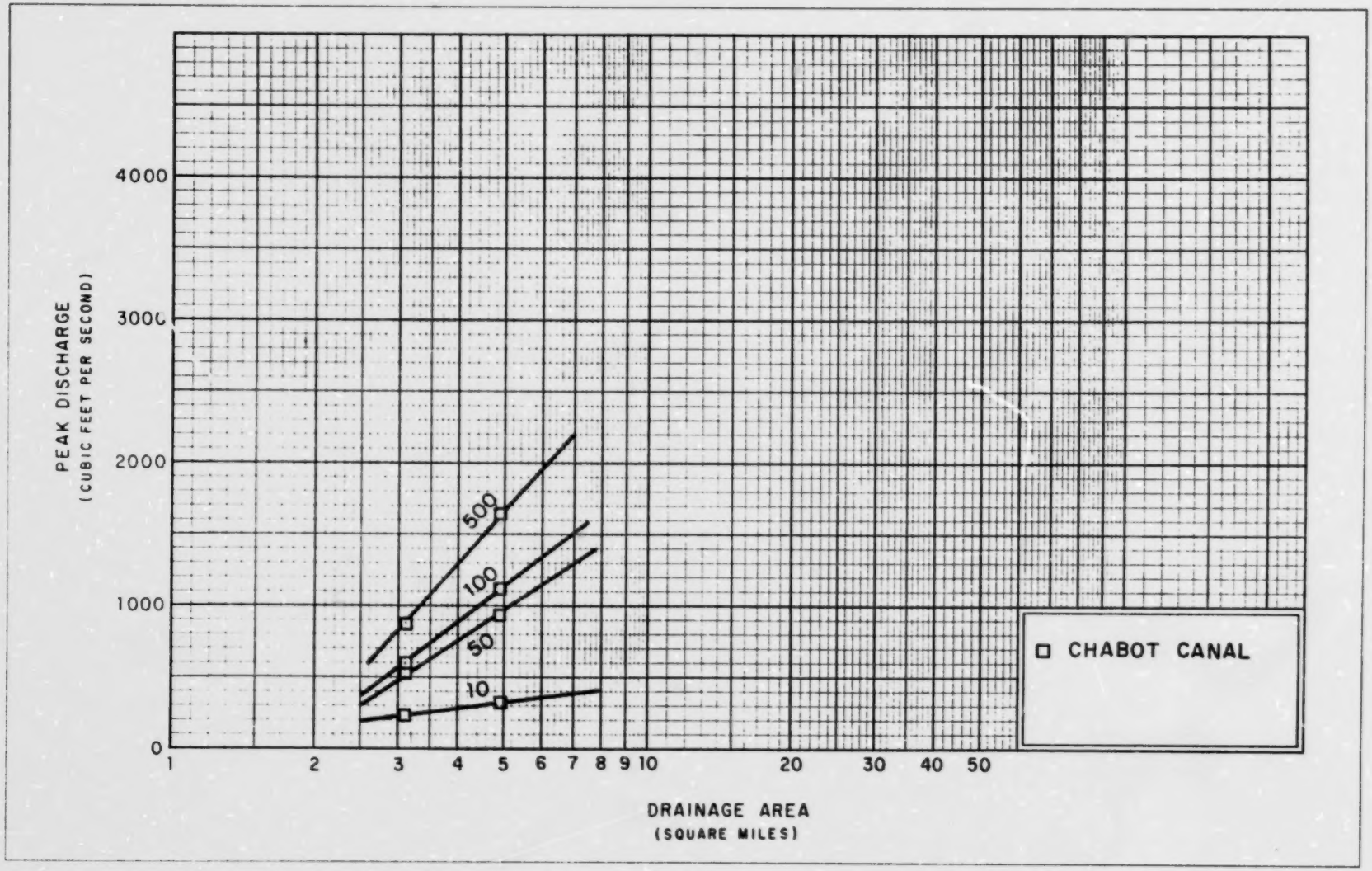


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CHABOT CANAL

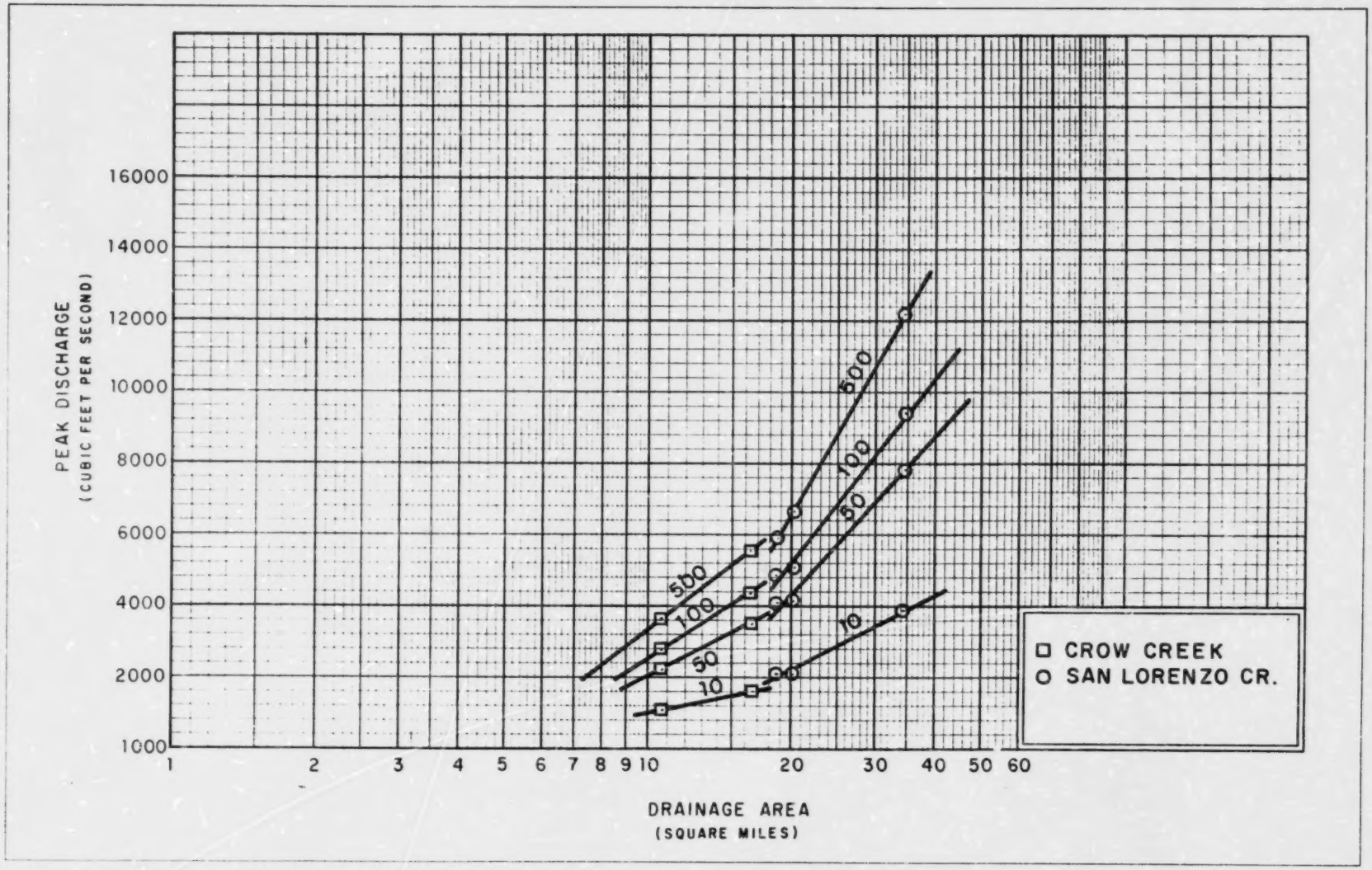


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CROW CREEK, SAN LORENZO CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

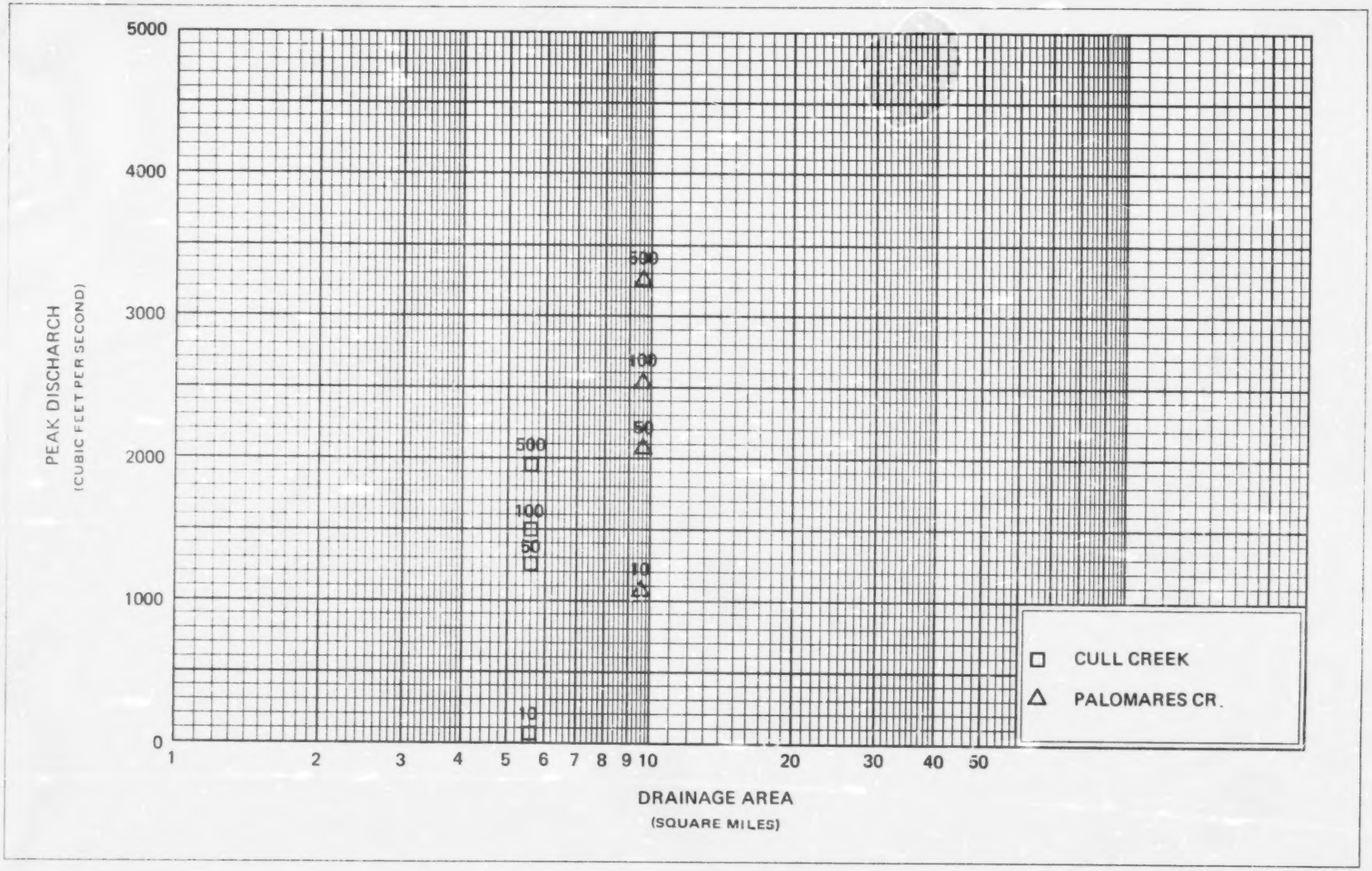


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CULL CREEK, PALOMARES CREEK

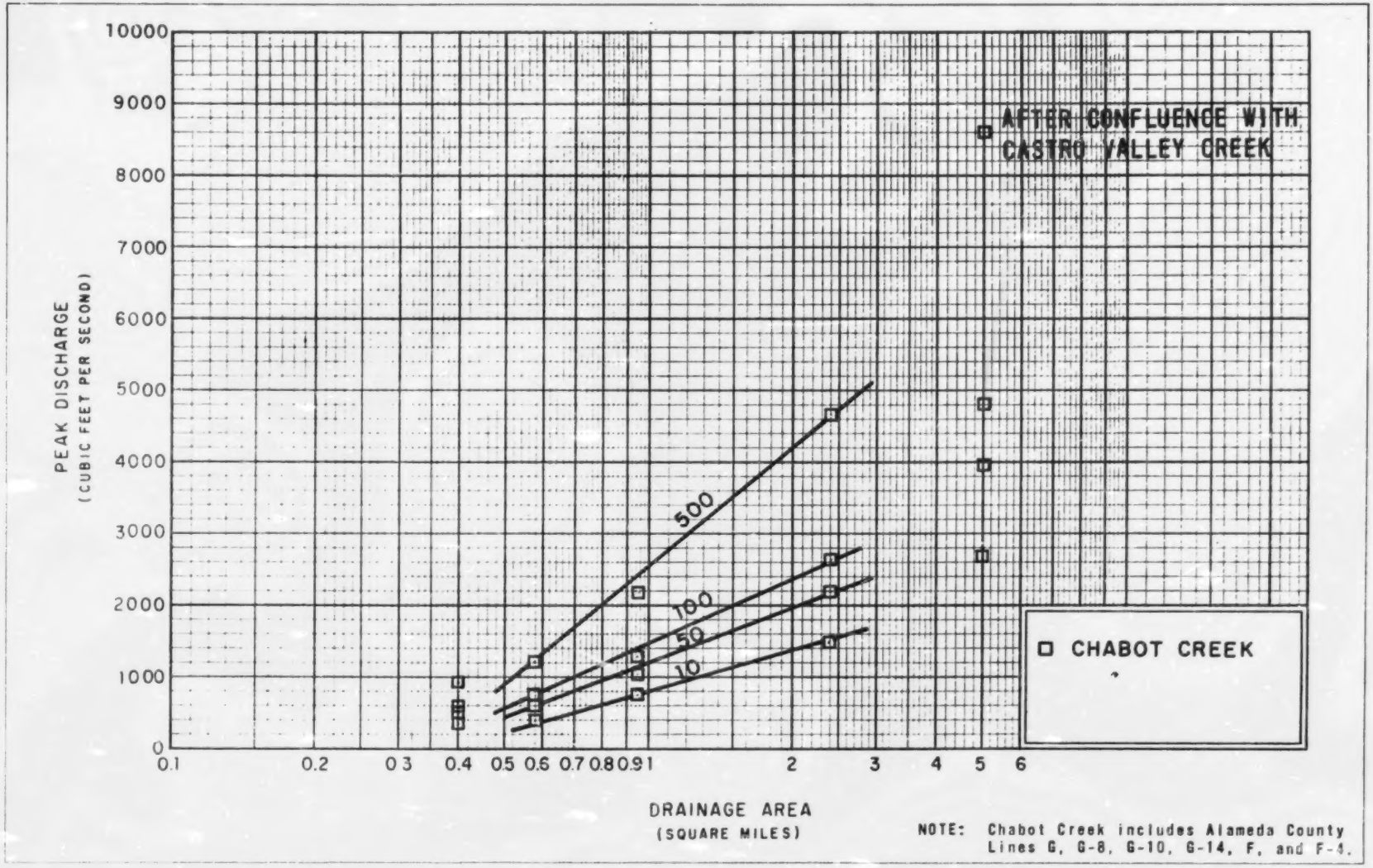


FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CHABOT CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

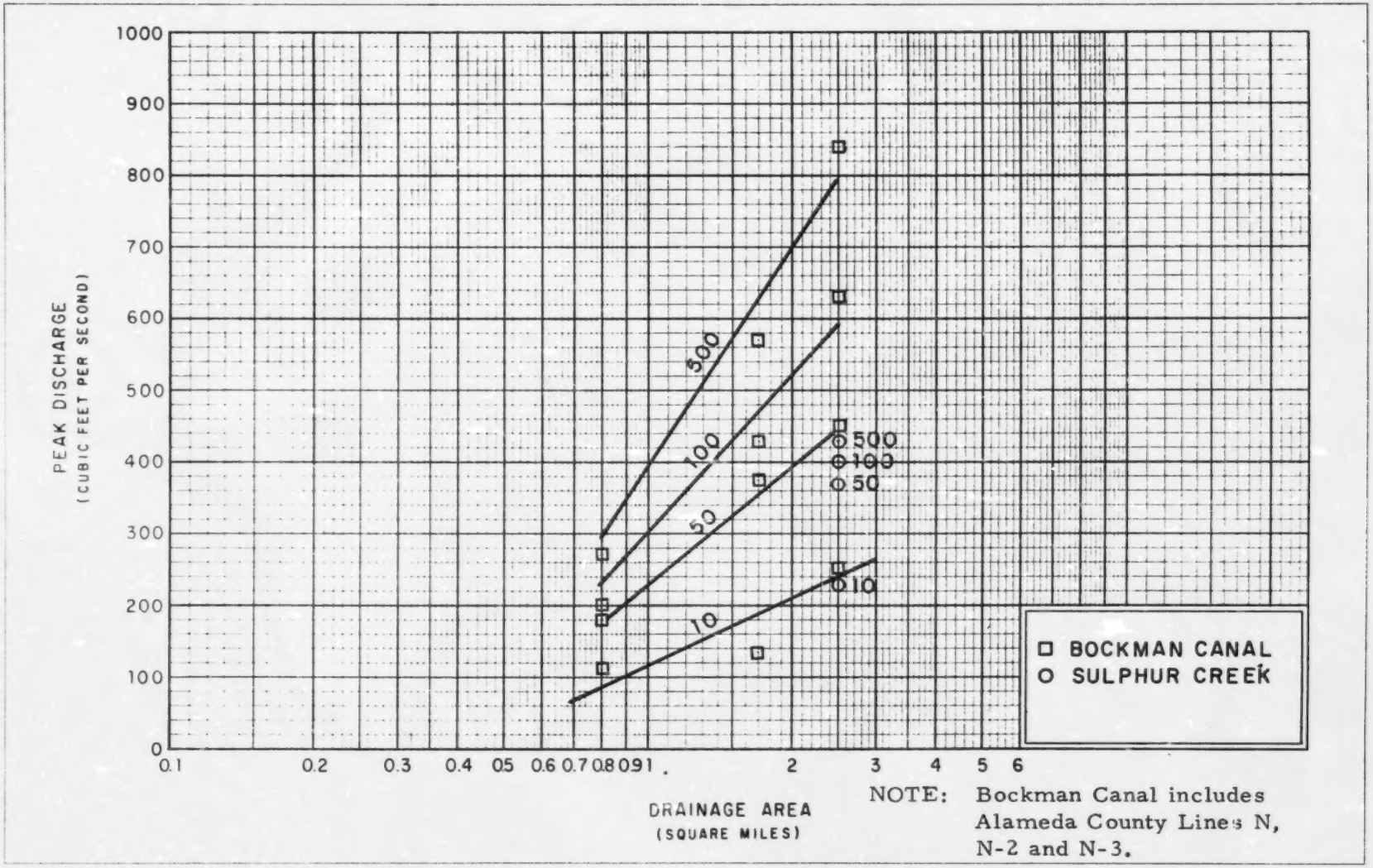


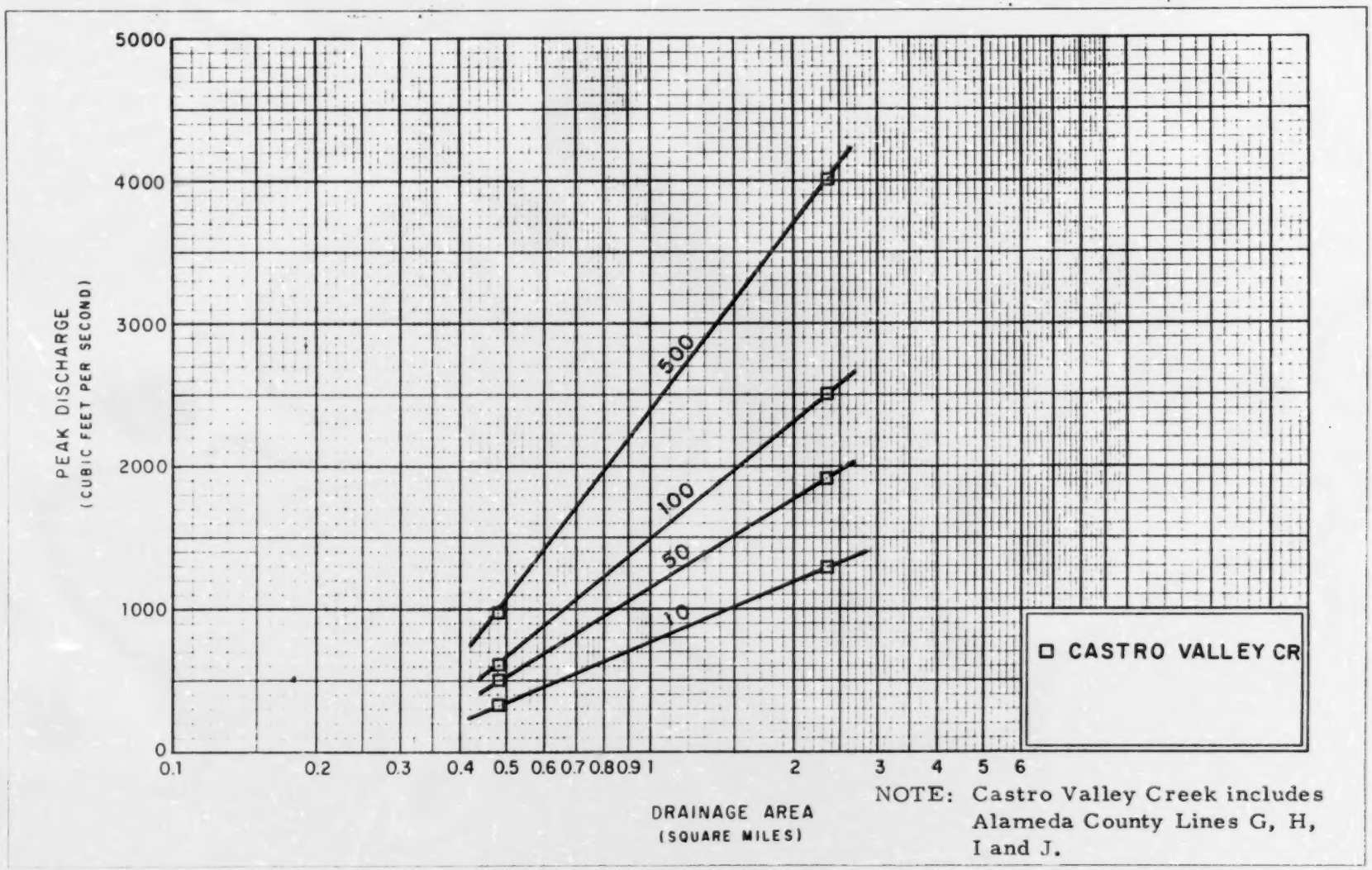
FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

BOCKMAN CANAL, SULPHUR CREEK



NOTE: Castro Valley Creek includes Alameda County Lines G, H, I and J.

FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CASTRO VALLEY CREEK

BEST COPY AVAILABLE

Creek upstream of the mouth of Niles Canyon, using the 84 years of recorded data at the USGS gage. The adopted frequency curve differs from the gage frequency curve because of the adjustment for the construction of Del Valle Reservoir upstream and greater urbanization of the Livermore Valley.

The Arroyo De La Laguna basin constitutes the northern portion of the Alameda Creek basin upstream of Sunol. All of the remaining streams studied in detail are located in the Arroyo De La Laguna basin.

In the Arroyo De La Laguna basin, streamflow gage records were insufficient to develop peak-flow frequency curves. The procedure followed was to use the available gages on Arroyo De La Laguna at Verona and on Arroyo Mocho at Livermore and Pleasanton as control points. Through the use of historical storms, unit hydrographs were derived at each of these locations. Then, using regional relationships of the lag-to-basin physical parameters, unit hydrographs were derived at all locations where flow frequency curves were desired.

Loss rates were derived for each storm in accordance with the Alameda County Flood Control and Water Conservation District procedures. The range of losses are as follows:

10-year	0.30 to 0.14 inches per hour
50-year	0.23 to 0.13 inches per hour
100-year	0.22 to 0.12 inches per hour
500-year	0.16 to 0.06 inches per hour

Rainfall frequency data developed by the California Department of Water Resources were used and a rainfall-runoff model was developed using the computer program HEC-1. Applying the derived unit hydrographs, the adopted loss rates, and rainfall for storms with frequencies of 10-, 50-, 100-, and 500-years, a peak-flow frequency curve was developed at each of the selected locations. Frequency curves were first adopted for the control points at the streamflow gages and frequency curves for adjacent subbasins were smoothed so as to result in a family of frequency curves for each basin.

c. The previous work of the COE on the frequency of occurrence of high tides in the San Francisco Bay was reviewed and the 10-, 50-, 100-, and 500-year high tides were established for flooding at the lower end of Bockman Canal and in the vicinity of Line N-3.

These tide heights were compared with tsunami wave runups, which were obtained from data developed for the San Francisco Bay, and the highest value was used.

BEST COPY AVAILABLE

The tidal frequency data are shown in Table 1.

The hydrologic analysis for Ward Creek - Line B (Zone 3A) was developed using a COE regionalized procedure for ungaged basins which analyzes runoff-rainfall phenomena peculiar to the San Francisco Bay area (Reference 11). The rainfall-frequency data were obtained from a California Department of Water Resources publication (Reference 12).

From these data, the watersheds contributing to the waterways to be studied and the key points on the streams where discharge-frequency relationships could be established were determined. Watershed characteristics of land coverage and runoff effect of lag and storage were also developed from these data.

The loss rates were then subtracted from the rainfall data, and rainfall hydrographs for the 10- and 100-year recurrence events were established. This rainfall was then applied to each subbasin using a ratio of mean annual precipitation of the watershed to the mean annual precipitation at the closest nearby rainfall gage in the unincorporated areas of the City of Niles. The computer program HEC-1 (Reference 10) was then used to model the basin and produce a hydrograph.

The resulting 10- and 100-year discharges were plotted for each key point on log probability paper to determine the flow-frequency curve. This curve was interpolated to determine the discharge for the 50-year flood and extrapolated to determine the discharge for the 500-year flood.

A portion of the floodflow is diverted from the Ward Creek - Line B (Zone 3A) flood plain into Line C (Zone 3A) upstream of the junction of Ward Creek - Line B (Zone 3A) with Line E (Zone 3A) in the City of Hayward.

Peak discharge-drainage area relationships for Ward Creek are shown in Table 2.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

The procedure used in the hydraulic analyses began with analyzing available mapping, including maps prepared by county and private agencies and USGS topographic maps. From this data a preliminary map study was made of the streams to be studied in detail.

Next, a field reconnaissance was conducted to investigate stream channels, obvious problem areas, channel and overbank roughness, flow restrictions, and structures such as bridges, culverts, and levees.

BEST COPY AVAILABLE

BEST COPY AVAILABLE

Table 1. Tidal Frequency (Feet NGVD)

Location	10-Year	50-Year	100-Year	500-Year
San Francisco Bay At the City of Hayward, North Corporate Limits	6.0	6.3	6.5	6.7

30

Table 2. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Ward Creek - Line B (Zone 3A) At Junction with Line D (Zone 3A)	8.81	1,640	2,800	3,460	5,100

BEST COPY AVAILABLE

Topographic data and mapping, including stream-channel cross sections, and structure dimensions and elevations were compiled from a variety of sources, and additional field surveys were conducted where necessary. Then, as-built construction plans for all water-control structures, channel modifications, bridges, culverts, and related facilities were compiled and reviewed.

A physical description of each channel was prepared and the invert and bank profiles were plotted. Controlling water-surface elevations were then determined. From these, water-surface profiles for events of 10-, 50-, 100-, and 500-years were calculated using standard engineering procedures, including the use of the computer model HEC-2 (Reference 13), where applicable.

Channel cross sections used to define the flood water-surface profiles are delineated on the Flood Boundary and Floodway Map (Exhibit 2). Additional cross sections were used to define bridges, culverts, and certain channel locations. These are not shown on the map.

Water-surface profiles were computed using the COE HEC-2 Water-Surface Profiles computer program (Reference 13). Use of the computer model was replaced or supplemented with hand calculations in certain areas and situations where such methods were considered to be more suitable.

The Manning flow formula was used in the computation of flow profiles. Channel roughness factors for channel and overbank areas (Manning's "n") were estimated based on field observations, review of photographs, review of previous studies, and comparison with other areas. Roughness coefficients vary widely throughout the study area. Channel configuration (whether natural or manmade), vegetation, land use in the overbank area adjacent to the channel, and other physical parameters all have an effect on flow. Values for roughness coefficients ranged from 0.014 for efficient concrete-lined channels to 0.045 for difficult natural channels with extensive undergrowth and from 0.035 to 0.050 for overbank areas.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

No profiles are shown for Bockman Canal and Lines N-2 and N-3 because these areas are under tidal influence from the San Francisco Bay.

BEST COPY AVAILABLE

Along Arroyo Mocho the flows between cross sections H and J are influenced by the levees. Consequently, elevations inside the levees are slightly different from those shown outside the levees.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program (NFIP) encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the county. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were extrapolated using a wide variety of topographic information assembled in a way to adequately define elevations along the channels and in the flood plains. Mapping and as-built channel data were obtained from the files of the Alameda County Flood Control and Water Conservation District; channel data obtained from the COE; strip mapping obtained from the California Department of Transportation; development mapping obtained from private owners, USGS quadrangle maps, park districts; and detail mapping from the State of California, Department of Water Resources data, the cities within the county, and field surveys by two survey contractors. From these major sources of information, sufficient data were established to determine the channel flood profiles and the limits of flooding. Once the required profiles and flooding limits were established and confirmed using the accurate channel data, the flooding limits were transferred to the work maps at a scale of 1:12,000. A detailed list of the data sources for each channel appears in Sources of Channel Data (Reference 14). A detailed listing of mapping sources can also be found in this data.

For the areas along Arroyo De La Laguna, north of Bernal Avenue and east of Foothill Road, flood boundaries were delineated using topographic maps at scales of 1:4,800; 1:1,200; and 1:480, with contour intervals of 1 foot, 2 feet, and 1 foot, respectively (References 15, 16, and 17).

BEST COPY AVAILABLE

For the areas along Ward Creek, flood boundaries were delineated using topographic maps at a scale of 1:24,000, with contour intervals of 10 and 20 feet, and aerial strip mapping at a scale of 1:4,800 with a contour interval of 1 foot (References 18, 19, and 20).

Tidal flooding from the San Francisco Bay was mapped using topographic maps at a scale of 1:24,000 with contour intervals of 10 and 20 feet (References 18 and 19).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 100-year flood plain boundary is shown.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal-conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 3).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown.

BEST COPY AVAILABLE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Alameda Creek							
A	97,300[1]	450	7,112	4.5	235.3	235.2	0.1[2]
B	102,100[1]	163	6,289	2.2	242.2	241.4	0.8
C	107,400[1]	1,200	3,773	3.2	255.6	254.9	0.7
Arroyo De La Laguna							
A	1,900[3]	480	8,391	2.0	236.6	235.6	1.0
B	3,560[3]	497	6,034	2.8	243.7	242.9	0.8
C	6,720[3]	155	2,300	7.4	255.1	254.1	1.0
D	8,520[3]	230	3,304	5.1	261.4	260.5	0.9
E	9,760[3]	300	3,030	5.6	264.9	263.9	1.0
F	10,455[3]	184	2,529	6.7	266.5	265.7	0.8
G	11,040[3]	292	3,930	4.3	268.1	267.2	0.9
H	14,990[3]	235	3,348	5.1	278.0	277.5	0.5
I	18,980[3]	174	2,711	6.3	288.4	288.2	0.2
J	22,990[3]	207	4,248	4.0	303.2	302.3	0.9
K	24,530[3]	141/41[4]	2,255	7.5	304.5	303.7	0.8
L	32,980[3]	172	3,243	5.2	318.0	318.0	0.0[5]

[1]Feet Above Mouth [2]Overbank Velocity Excessive [3]Feet Above Confluence With Alameda Creek
[4]Width/Width Within County Limits [5]Floodway Is Confined to Main Channel

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ALAMEDA CREEK-ARROYO DE LA LAGUNA

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Arroyo Mocho							
A	14,235	507/100[2]	2,100	5.3	342.8	342.5	0.3
B	16,700	1,122	4,107	5.0	347.9	347.3	0.6
C	18,100	1,080	4,290	2.6	353.0	352.0	1.0
D	20,014	1,116	4,607	2.2	357.4	356.5	0.9
E	22,047	1,459	5,477	2.0	361.6	361.3	0.3
F	24,650	1,050	2,196	2.5	364.0	363.0	1.0
G (Rt Bank)	27,633	880	1,372	3.0	374.8	374.0	0.8
G (Main Channel)	27,633	80	500	2.4	376.0	375.0	1.0
H (Rt Bank)	29,300	700	2,493	0.7	379.4	378.5	0.9
H (Main Channel)	29,300	100	295	4.0	380.0	380.0	0.0
I (Rt Bank)	32,152	1,006	633	2.5	389.9	389.0	0.9
I (Lt Bank)	32,152	186	189	3.7	391.8	391.3	0.5
I (Main Channel)	32,152	80	550	5.7	396.2	396.2	0.0
J	33,350	850	3,042	1.7	403.2	402.2	1.0[3]
K	35,800	100	525	10.0	415.2	415.2	0.0[4]
L	39,650	380	1,338	4.0	436.4	436.4	0.0

[1]Feet Above Mouth [2]Width/Width Within County Limits [3]Floodway Is Confined to Main Channel [4]Overbank Velocity Excessive

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO MOCHO

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Arroyo Mocho (Cont'd)							
M	53,500	618[2]	1,329	4.1	541.9	541.9	0.0[3]
N	54,660	520[2]	1,493	3.1	552.6	551.6	1.0[4]
O	55,700	425	1,038	4.5	561.5	561.5	0.0[4]
P	56,725	281	561	8.6	573.9	573.5	0.4
Q	59,775	88	624	7.5	598.3	597.7	0.6
R	59,77	77	462	9.8	602.0	601.4	0.6
S	60,775	83	468	9.7	609.8	609.6	0.2
T	61,725	124	557	8.2	616.9	616.9	0.0
U	62,675	155	473	9.6	628.5	628.5	0.0

[1]Feet Above Mouth [2]This Width Extends Beyond County Limits [3]Floodway Stays Outside of Main Channel [4]Overbank Velocity Excessive

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO MOCHO

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Arroyo Las Positas[2]							
(B)	1,000	1,122	4,107	5.00	347.9	347.3	0.6
(C)	2,270	1,080	4,290	2.60	353.0	352.0	1.0
(D)	4,200	1,116	4,607	2.20	357.4	356.5	0.9
(E)	6,118	1,459	5,477	2.04	361.6	361.3	0.3
A	9,500	450	2,260	2.60	372.6	371.6	1.0
B	39,340	99	474	4.80	495.2	494.4	0.8
C	40,163	220	866	2.70	497.7	496.7	1.0
D	41,259	202	963	1.50	498.5	497.5	1.0
E	51,767	420	6,969	0.10	528.2	527.2	1.0

[1]Feet Above Confluence With Arroyo Mocho [2]Floodway Is Common to Both Arroyo Las Positas and Arroyo Mocho

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO LAS POSITAS

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Arroyo Seco							
A	7,319	1,372[2]	7,778	0.2	536.5	535.5	1.0
B	8,619	45	148	9.3	541.2	540.2	1.0[3]
C	9,920	45	1,742	0.7	550.5	549.5	1.0[3]

[1]Feet Above Mouth [2]Width Shown Without Consideration of Floodway for Arroyo Las Positas Relocation [3]Floodway Is Confined to Main Channel

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO SECO

BEST COPY AVAILABLE

BLANK PAGE

BLANK PAGE

BLANK PAGE

BEST COPY AVAILABLE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Arroyo Las Positas Relocation							
A	3,000	176[2]	302	2.7	549.0	548.2	0.8
B	4,000	140	300	2.7	553.8	552.8	1.0
C	8,300	150	225	3.6	576.3	575.3	1.0[3]
D	10,300	17	79	10.4	590.4	589.4	1.0
E	17,100	87	121	6.8	682.8	682.8	0.0
F	18,500	34	136	6.0	714.7	713.7	1.0

[1]Feet Above Confluence With Arroyo Seco [2]This Width Extends Beyond County Limits
[3]1 Foot Above Right Bank Elevation 591.5 Feet

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO LAS POSITAS RELOCATION

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Arroyo Del Valle							
A	14,150[1]	124[2]	824	8.5	348.7	348.7	0.0
B	20,650[1]	430	*	*	*	*	*
C	28,950[1]	405	*	*	*	*	*
D	32,250[1]	435	*	*	*	*	*
E	39,250[1]	150	769	9.1	443.7	443.0	0.7
F	42,550[1]	350	1,327	5.3	462.1	461.1	1.0
G	44,750[1]	320	1,905	3.7	477.5	476.5	1.0
H	48,250[1]	510	1,400	5.0	495.3	494.5	0.8
I	55,850[1]	155	1,149	6.1	546.8	546.0	0.8
J	57,550[1]	135	1,116	6.3	557.7	556.7	1.0
Tassajara Creek							
A	8,000[3]	133	530	4.3	353.9	353.3	0.6
B	10,987[3]	39	241	9.4	365.1	364.1	1.0
C	11,391[3]	170	789	2.9	369.5	368.5	1.0
D	12,275[3]	100	608	3.7	377.0	376.0	1.0

[1]Feet Above Confluence With Arroyo De La Laguna
[2]This Width Extends Beyond County Limits
[3]Feet Above Confluence With Arroyo Mocho
*Data Not Available

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO DEL VALLE-TASSAJARA CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Cayetano Creek							
A	5,670	89	145	6.6	479.2	479.2	0.0[2]
B	9,000	89	217	4.4	506.2	505.2	1.0[2]
C	14,800	44	152	6.3	538.6	537.8	0.8[2]
D	16,551	40	197	4.8	557.4	556.7	0.7[2]
E	17,650	239	570	1.7	562.4	561.4	1.0[2]
F	21,500	152	100	2.4	585.3	585.2	0.1[2]

[1]Feet Above Mouth [2]Floodway Stays Outside Main Channel

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

CAYETANO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Cayetano Creek (West Branch)							
A	2,000	118	59	4.1	603.1	603.1	0.0[2]
Altamont Creek							
A	11,000	210	191	3.8	546.1	545.9	0.2
B	12,380	102	328	2.2	552.8	551.9	0.9
C	13,600	30	92	7.8	559.1	558.6	0.5
D	15,800	198	386	1.9	567.4	567.2	0.2
E	17,400	61	210	3.4	578.6	578.0	0.6

[1]Feet Above Mouth [2]Floodway Is Confined to Main Channel

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

CAYETANO CREEK (WEST BRANCH)-ALTAMONT CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION		
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	WITH FLOODWAY	WITHOUT FLOODWAY (FEET NGVD)	DIFFERENCE
Cayetano Creek							
A	5,670	89	145	6.6	479.2	479.2	0.0[2]
B	9,000	89	217	4.4	506.2	505.2	1.0[2]
C	14,800	44	152	6.3	538.6	537.8	0.8[2]
D	16,551	40	197	4.8	557.4	556.7	0.7[2]
E	17,650	239	570	1.7	562.4	561.4	1.0[2]
F	21,500	152	100	2.4	585.3	585.2	0.1[2]

[1]Feet Above Mouth [2]Floodway Stays Outside Main Channel

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

CAYETANO CREEK

No floodway was computed for Bockman Canal because of its tidal influence.

On Ward Creek - Line B (Zone 3A), the 100-year flood is confined to the channel; therefore, no floodway was computed.

Along Arroyo Mocho, where the flood levels are influenced by levees, separate flows exist. Therefore, separate floodway widths are shown in Table 3.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 3.

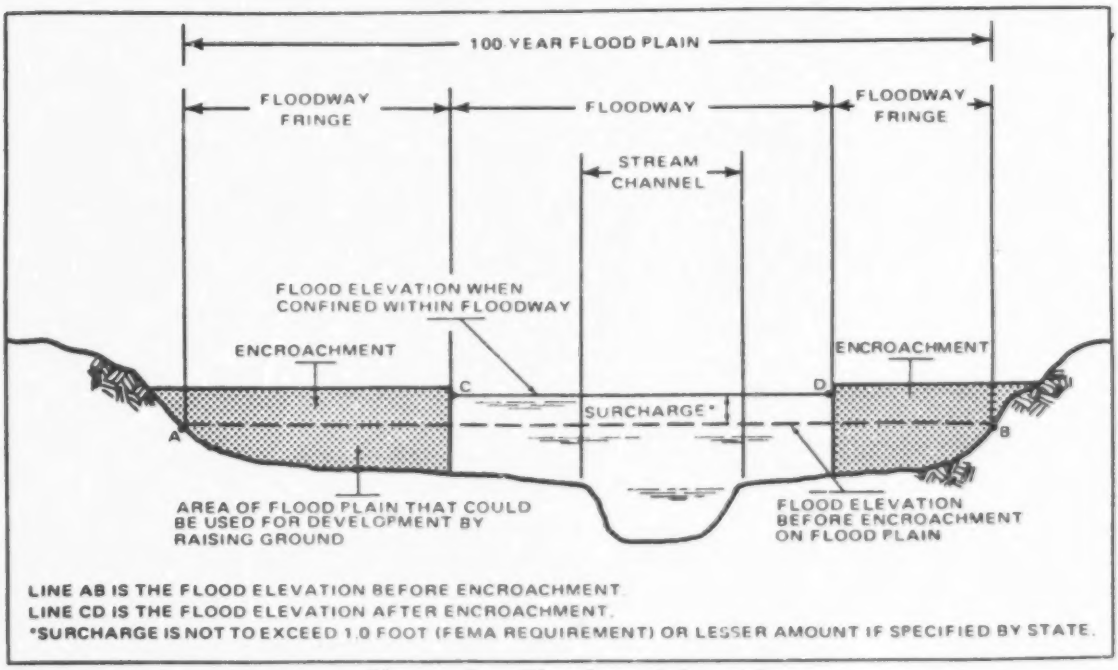

100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

Figure 3. Floodway Schematic

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the unincorporated areas of Alameda County.

BEST COPY AVAILABLE

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Alameda County are shown on the Flood Profiles (Exhibit 1) and summarized in Table 4.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.

Zone AO: Special Flood Hazard Areas inundated by types of 100-year shallow flooding where

BEST COPY AVAILABLE

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Alameda Creek							
Reach 1	0195,0215	-7.3	-1.3	4.2	075	A15	Varies - See Map
Reach 2	0215	-1.1	-0.5	0.7	010	A2	Varies - See Map
Arroyo De La Laguna							
Reach 1	0205,0215	-0.6	-1.7	3.7	060	A12	Varies - See Map
Reach 2	0205	-7.6	-2.0	4.9	075	A15	Varies - See Map
Reach 3	0205	-8.1	-2.3	5.2	080	A16	Varies - See Map
Ponding Area	0205	N/A	N/A	N/A	N/A	AH	318
Arroyo Mocho							
Reach 1	0115	-7.4	-1.1	2.8	075	A15	Varies - See Map
Reach 2	0115,0205	-1.7	-0.5	0.8	015	A3	Varies - See Map
Reach 3	0205,0210	-0.3	-0.1	0.2	005	A1	Varies - See Map
Reach 4	0205,0210	-3.3	-0.7	1.2	025	A7	Varies - See Map
Reach 5	0210	-2.4	-0.8	1.2	025	A5	Varies - See Map
Arroyo Las Positas							
Reach 1	0115,0205	-1.7	-0.5	0.9	015	A3	Varies - See Map
Reach 2	0115	-2.7	-0.8	1.4	025	A5	Varies - See Map
Reach 3	0210	-3.6	-1.1	2.9	035	A7	Varies - See Map
Reach 4	0210	-2.6	-0.8	2.4	025	A5	Varies - See Map
Reach 5	0210	-4.2	-1.0	2.4	040	A8	Varies - See Map
Reach 6	0120,0210	-2.3	-0.9	1.1	025	A5	Varies - See Map
Reach 7	0120	-1.7	-0.6	0.7	015	A3	Varies - See Map
Reach 8	0120,0210	-0.6	-0.1	0.2	005	A1	Varies - See Map
Shallow Flooding Area	0120,0210	N/A	N/A	N/A	N/A	AO	Depth 2

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

ALAMEDA CREEK-ARROYO DE LA LAGUNA-ARROYO MOCHO-ARROYO LAS POSITAS

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND 10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)	FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
Arroyo Seco							
Reach 1	0210	-3.8	-1.1	3.0	040	A8	Varies - See Map
Reach 2	0210,0230	-2.2	-0.4	0.2	020	A4	Varies - See Map
Reach 3	0210,0230	-3.1	-1.0	2.0	030	A6	Varies - See Map
Reach 4	0230	-1.6	-0.7	1.5	015	A3	Varies - See Map
Shallow Flooding Area	0210	N/A	N/A	N/A	N/A	AO	Depth 1
Arroyo Las Positas Relocation							
Reach 1							
Ponding Area	0210,0230	-0.8	-0.4	0.3	010	A2	Varies - See Map
	0230	N/A	N/A	N/A	N/A	AH	630
Arroyo Del Valle							
Reach 1	0205	-4.6	-2.2	1.1	045	A9	Varies - See Map
Reach 2	0210,0220	-1.3	-0.7	0.6	015	A3	Varies - See Map
Reach 3	0220	-3.1	-1.6	1.0	030	A6	Varies - See Map
Tassajara Creek							
Reach 1	0115	-3.0	-0.8	1.3	030	A6	Varies - See Map
Cottonwood Creek							
Reach 1	0115,0120	-1.0	-0.4	0.5	010	A2	Varies - See Map
Collier Creek							
Reach 1	0120	-1.7	-0.6	0.6	015	A3	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

ARROYO SECO-ARROYO LAS POSITAS RELOCATION-ARROYO DEL VALLE-
TASSAJARA CREEK-COTTONWOOD CREEK-COLLIER CREEK

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Cayetano Creek							
Reach 1	0210	-3.6	-1.1	3.6	035	A7	Varies - See Map
Reach 2	0120	-1.3	-0.6	0.7	015	A3	Varies - See Map
Reach 3	0120	-1.8	-0.8	0.8	020	A4	Varies - See Map
Reach 4	0120	-0.8	-0.4	0.4	010	A2	Varies - See Map
Cayetano Creek (West Branch)							
Reach 1	0120	-0.8	-0.4	0.4	010	A2	Varies - See Map
Reach 2	0120	-0.6	-0.3	0.3	005	A1	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

CAYETANO CREEK-CAYETANO CREEK (WEST BRANCH)

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Altamont Creek							
Reach 1	0140	-1.0	-0.4	0.4	010	A2	Varies - See Map
Reach 2	0140	-1.7	-0.6	0.9	015	A3	Varies - See Map
Dublin Creek							
Reach 1	0095,0115	-3.5	-0.5	0.6	035	A7	Varies - See Map
Reach 2	0095	-1.2	-0.6	0.7	010	A2	Varies - See Map
Chabot Canal							
Reach 1	0115	-2.2	-0.4	0.5	020	A4	Varies - See Map
San Lorenzo Creek							
Reach 1	0090	-4.7	-1.3	2.0	045	A9	Varies - See Map
Reach 2	0090,0095	-7.0	-1.6	2.5	070	A14	Varies - See Map
Reach 3	0095	-4.0	-0.9	1.2	040	A8	Varies - See Map
Reach 4	0095	-4.8	-1.3	1.7	050	A10	Varies - See Map
Reach 5	0095	-6.8	-2.0	3.5	070	A14	Varies - See Map
Reach 6	0095	-7.9	-2.4	1.5	080	A16	Varies - See Map
Reach 7	0095	-4.4	-1.1	1.5	045	A9	Varies - See Map
Palomares Creek							
Reach 1	0095	-2.3	-0.7	0.8	025	A5	Varies - See Map
Cull Creek							
Reach 1	0095	-5.8	-1.0	1.8	060	A12	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

ALTAMONT CREEK-DUBLIN CREEK-CHABOT CANAL-SAN LORENZO CREEK-PALOMARES CREEK-CULL CREEK

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Crow Creek							
Reach 1	0090,0095	-5.7	-1.3	2.3	055	A11	Varies - See Map
Reach 2	0085,0095	-4.2	-1.2	1.4	040	A8	Varies - See Map
Chabot Creek (Line G)							
Reach 1	0090	-2.6	-0.8	2.4	025	A5	Varies - See Map
Reach 2	0090	-1.0	-0.4	0.7	010	A2	Varies - See Map
Reach 3	0090	-2.4	-0.1	0.1	025	A5	Varies - See Map
Reach 4	0090	-0.2	-0.1	0.3	005	A1	Varies - See Map
Castro Valley Creek (Line I)							
Reach 1	0090	-1.5	-0.6	1.8	015	A3	Varies - See Map
Reach 2	0090	-0.7	-0.3	0.5	005	A1	Varies - See Map
Castro Valley Creek (Line J)							
Reach 1	0090	-2.2	-1.1	2.4	020	A4	Varies - See Map
Reach 2	0090	-4.0	-2.5	0.8	040	A8	Varies - See Map
Reach 3	0090,0095	-1.5	-0.8	1.3	015	A3	Varies - See Map
Shallow Flooding Area	0090	N/A	N/A	N/A	N/A	AO	Depth 2
Sulphur Creek							
Reach 1	0090	-1.3	-0.2	0.2	015	A3	Varies - See Map
Shallow Flooding Area	0090	N/A	N/A	N/A	N/A	AO	Depth 2

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

CROW CREEK-CHABOT CREEK (LINE G)-CASTRO VALLEY CREEK (LINE I)-CASTRO VALLEY CREEK (LINE J)-SULPHUR CREEK

BEST COPY AVAILABLE

BEST COPY AVAILABLE

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Ward Creek - Line B (Zone 3A)							
Reach 1	0180	-1.6	-0.1	0.3	015	A3	Varies - See Map
Reach 2	0180	-3.1	-1.1	1.4	030	A6	Varies - See Map
San Francisco Bay							
Reach 1	0090,0180	-0.5	-0.2	0.2	005	A1	7
Reach 2	0090	-0.5	-0.2	0.2	005	V1	7

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

ALAMEDA COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

WARD CREEK-LINE B (ZONE 3A)–SAN FRANCISCO BAY

depths are between 1.0 and 3.0 feet; depths are shown, but no FHFs are determined.

Zone AH: Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no FHFs are determined.

Zone V1: Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater; with base flood elevations shown, and zones subdivided according to FHFs.

Zones A1-A12, and A14-A16: Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.

Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other local water-control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flood hazard; not subdivided.

Zone D: Areas of undetermined, but possible flood hazard.

The flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the county are summarized in Table 4.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Alameda County is, for insurance purposes, the principal product of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the loca-

BEST COPY AVAILABLE

tions of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the NFIP.

Some Flood Insurance Zones are not shown on the Flood Insurance Rate Map due to containment of the 100-year flood within the stream channel. For portions of streams where Flood Insurance Zones are not shown on the map, refer to the Flood Profiles (Exhibit 1).

6.0 OTHER STUDIES

The results of this study are in concurrence with two previous flood-control reports by the COE, Operation and Maintenance Manual for San Lorenzo Creek: Flood Control Project, Alameda County, California (Reference 21); and General Design Memorandum, San Lorenzo Creek Flood Control Project, Alameda County, California (Reference 22).

Frequency curves were updated to represent the current level of development in a manner consistent with projections contained in the COE reports (References 21 and 22).

Flood Insurance Studies have been completed for the Cities of Livermore, Pleasanton, Fremont, Hayward, Oakland, Berkeley, Union City, and Dublin (References 23 through 30, respectively), and are in general agreement with the Alameda County Flood Insurance Study.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, FEMA, Building 105, Presidio of San Francisco, San Francisco, California 94129.

8.0 BIBLIOGRAPHY AND REFERENCES

1. U.S. Department of the Army, Corps of Engineers, San Francisco District, Review Report for Flood Control and Allied Purposes; Alameda Creek; Appendices, 1961

2. California Department of Finance, Budget Division, California Statistical Abstract, 1974

3. Alameda County Planning Commission, Unpublished Data: Interim Population Projections, Alameda County, 1972

BEST COPY AVAILABLE

4. U.S. Department of Commerce, Bureau of Census, Census of Population, 1971

5. Alameda County Planning Commission, Economic Study of Eden Planning Unit (Draft), J.K. Decker, 1973

6. George P. Miller, Chronology of Events; Alameda Creek and Tributaries, 1960

7. U.S. Department of the Army, Corps of Engineers, San Francisco District, General Design Memorandum, San Lorenzo Creek Flood Control Project, Alameda County, California, 1958

8. "Rain Havoc in South County," Hayward Daily Review, December 23, 1964

9. Alameda County Planning Commission, Open Space Element of the General Plan: County of Alameda, State of California, 1973

10. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, 1973

11. U.S. Department of the Army, Corps of Engineers, San Francisco District, Lag Relationship and S-Curve Hydrograph Procedures, June 1974

12. California Department of Water Resources, California Resources Agency, Summary of Short-Duration Precipitation Frequency in the San Francisco Bay Area, December 1974

13. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Flood Hydrograph Package, Davis, California, October 1973

14. Development and Resources Corporation, Sources of Channel Data, (Supplemental Data), March 1976

15. Bissell & Karn, Inc., Flood Water Hazard Map, Pleasanton, California, Scale 1:4,800, Contour Interval 1 foot, 1983

16. Aero-Geodetic Corporation, Topographic and Boundary Survey Pleasanton, California, Scale 1:1,200, Contour Interval 2 feet, November 1982

17. Aero-Geodetic Corporation, Topographic and Boundary Survey, Pleasanton, California, Scale 1:480, Contour Interval 1 foot, April 1983

18. Development and Resources Corporation, Topographic Maps, Scale 1:24,000, Contour Interval 10 feet: Hayward, California (1963), Photorevised (1973)

BEST COPY AVAILABLE

19. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 20 feet: Newark, California (1959), Photorevised (1980); Hayward, California (1959), Photorevised (1968) and (1973); San Leandro, California (1959), Photorevised (1980)

20. The Spink Corporation, Aerial Strip Mapping, Scale 1:4,800, Contour Interval 1 foot: Hayward, California (December 1977)

21. U.S. Department of the Army, Corps of Engineers, San Francisco District, Operation and Maintenance Manual for San Lorenzo Creek: Flood Control Project; Alameda County, California, 1963

22. U.S. Department of the Army, Corps of Engineers, San Francisco District, General Design Memorandum, San Lorenzo Creek Flood Control Project, Alameda County, California, 1958

23. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Livermore, California, 1975

24. Federal Emergency Management Agency, Flood Insurance Study, City of Pleasanton, California, 1982

25. Federal Emergency Management Agency, Flood Insurance Study, City of Fremont, California, 1983

26. Federal Emergency Management Agency, Flood Insurance Study, City of Hayward, California, 1981

27. Federal Emergency Management Agency, Flood Insurance Study, City of Oakland, Alameda County, California, 1982

28. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Berkeley, California, 1978

29. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Union City, California, 1978

30. Federal Emergency Management Agency, Flood Insurance Study, City of Dublin, California, 1983

Alameda County Flood Control and Water Conservation District, Dam Failure Inundation Report and Maps for San Lorenzo Creek Dam, Ward Creek Dam, and Cull Creek Dam, Hayward, California, 1974

Alameda County Planning Commission, Economic Study of Eden Planning Unit, J.K. Decker, 1973

BEST COPY AVAILABLE

Alameda County Planning Commission, General Plan, County of Alameda, Hayward, California, 1966

Alameda County Flood Control Water Conservation District, Open Space Element of the General Plan: County of Alameda, State of Calfornia, 1973

California Business and Transportation Agency, Department of Public Works, Division of Highways, District 04 Map, Sacramento, California

California Department of Finance, Budget Division, California Statistical Abstract, Sacramento, California, 1974

California Department of Transportation, Bridge Structure and State Highway Plans, Sacramento, California

California Department of Water Resources, Bulletin 130 (series), Hydrologic Data Report, Sacramento, California

California Department of Water Resources, Bulletin 1, Natural Runoff, Sacramento, California

California Department of Water Resources, Hydrologic Data Computation Number 17, Atlas of Rainfall Frequency in California, J.D. Goodridge, 1974

California Department of Water Resources, Simplified Watershed Analysis, Water-Loss Depth, Duration Frequency on Selected Watersheds in California, J.D. Goodridge, 1973

California Department of Water Resources, Specification Number 63-16, Specifications Proposal and Contract for Construction of Del Valle and Sunol Pipelines - Station A861-28.65 to Station N497-70.00, Alameda Division and Niles Division, South Bay Aqueduct, State Water Facilities, 1963

Hayward Daily Review, Hayward, California, December 23-27, 1955; October 14, 1962; December 23, 1964 - January 6, 1965; January 21-23, 1970

Lindsley, R.K. and J.B. Franzini, Water-Resources Engineering, New York: McGraw-Hill, Inc., 1972

Livermore Planning Department, General Plan, Livermore, California, 1964 (amended through 1975)

McCann, W.E., and E.J. Hinkel, "History of Rural Alameda County," 1937

Miller, George P., "Chronology of Events: Alameda Creek and Tributaries," 1960

BEST COPY AVAILABLE

Portland Cement Association, Handbook of Concrete Culvert Pipe Hydraulics, Skokie, Illinois, 1964

Thomas Brothers Maps, Alameda County Popular Street Atlas with Cross Street Index, San Francisco, California

Tri-Valley Herald, Livermore, California, March 30, 1907; January 17-18, 1952; December 30, 1955; April 1, 1958; October 16, 1962

U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, 1973

U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water-Surface Profiles, Davis, California, 1973

U.S. Department of the Army, Corps of Engineers, General Design Memorandum, San Lorezno Creek Flood Control Project, Alameda County, California, 1958 - Supplement A, Equivalent Construction Performed by Local Interest in Lieu of Cash Contributions, 1959

U.S. Department of the Army, Corps of Engineers, Review Report for Flood Control and Allied Purposes: Alameda Creek; Appendices, 1961

U.S. Department of the Army, Corps of Engineers, Water Resources Development, 1959 (supplement 1972)

U.S. Department of the Army, Corps of Engineers, Sacramento District, Regional Frequency Computation, Sacramento, California, 1972

U.S. Department of the Army, Corps of Engineers, San Francisco District, Design Memorandum No. 1, General Design Memorandum, Alameda Creek Flood Control Project and Appendix A, San Francisco, California, 1964

U.S. Department of Commerce, Bureau of Census, Census of Population, 1971

U.S. Department of Commerce, National Weather Service, Precipitation-Frequency Maps for California, Prepared for U.S. Department of Agriculture, Soil Conservation Service, 1972

U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study Guidelines and Specifications, 1975

U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1965

BEST COPY AVAILABLE

U.S. Department of the Interior, Geological Survey, Roughness Characteristics of Natural Channels, H.H. Barnes, 1967

U.S. Department of the Interior, Geological Survey, Menlo Park, California, prepared in cooperation with the U.S. Department of Housing and Urban Development, Suggested Criteria for Hydrologic Design of Storm-Drain Facilities in the San Francisco Bay Region, California, S.E. Rantz, 1971

U.S. Department of the Interior, Geological Survey, prepared in cooperation with California Department of Water Resources, California Steamflow Characteristics, Volume 1: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley, 1971

U.S. Department of the Interior, Geological Survey, prepared in cooperation with California Department of Water Resources, Water-Surface Data for California, Part 1, Surface Water Records, Volume 1: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley, 1968-1972

U.S. Department of the Interior, Geological Survey, Availability of Data on Surface-Water Quantity and Quality in the San Francisco Bay Region, California, with a Summary of Beneficial Uses and Implications for Land Use, Joseph Goss, 1974

U.S. Department of the Interior, Geological Survey, prepared in cooperation with the U.S. Department of Housing and Urban Development, Estimated Relative Abundance of Landslides in the San Francisco Bay Region, California, Dorothy H. Radbrunch and Carl Wentworth, 1971

U.S. Department of the Interior, Geological Survey, Water Resources Investigations 37-73, Open-File Report, SHT #3, Flood-Prone Area Map for the San Francisco Bay Region, California, J.T. Limerinos, K.W. Lee, P.E. Logo, 1973

U.S. Department of the Interior, Geological Survey, Floods at Fremont, California, 1962

U.S. Department of the Interior, Geological Survey, Land Subsidence in the Santa Clara Valley, Alameda, San Mateo, and Santa Clara Counties, California, J.F. Poland, 1971

U.S. Department of the Interior, Geological Survey, Maps Showing Distribution and Cost by Counties of Structurally Damaging Landslides in the San Francisco Bay Region, California, Winter of 1968-1969, Fred A. Taylor and Earl E. Brabb, 1972

U.S. Department of the Interior, Geological Survey, Mean Annual Precipitation and Precipitation Depth-Duration-Frequency Data for the San Francisco Bay Region, California, S.E. Rantz, 1971

BEST COPY AVAILABLE

U.S. Department of the Interior, Geological Survey, Precipitation Depth-Duration-Frequency Relations for the San Francisco Bay Region, California, S.E. Rantz, 1971

U.S. Department of the Interior, Geological Survey, Preliminary Photointerpretation Map of Landslide and Other Surficial Deposits of the Livermore and Part of Hayward 15-Minute Quadrangles, Alameda and Contra Costa Counties, California, Tor H. Nilsen, 1973

U.S. Department of the Interior, Geological Survey, Menlo Park, California, Preliminary Photointerpretation Map of Landslide and Other Surficial Deposits of the Mount Diablo Area, Contra Costa and Alameda Counties, California, Tor H. Nilsen, 1971

U.S. Department of the Interior, Geological Survey, San Francisco Bay Region Land Use Maps, 1974

U.S. Department of the Interior, Geological Survey, Suggested Criteria for Hydrologic Design of Storm-Drainage Facilities in the San Francisco Bay Region, California, S.E. Rantz, 1971

U.S. Department of the Interior, Geological Survey, A Summary View of Water Supply and Demand in the San Francisco Bay Region, California, S.E. Rantz, 1972

U.S. Water Resources Council, "A Uniform Technique for Determining Flood Flow Frequencies," Bulletin No. 15, 1967

BEST COPY AVAILABLE